

Castlegar Air Quality

**A Compilation and Synopsis of
Ambient Air Quality and
Industrial Emissions Data
1975 – 1985**



Ministry of Environment and Parks

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A Compilation and Synopsis of Ambient Air Quality and Industrial Emissions Data

1975 - 1986

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Executive Summary

This report has been prepared by the British Columbia Ministry of Environment and Parks, Kootenay Regional Operations, to present air quality data gathered in Castlegar, B.C. during the period 1975 - 1986. It discusses long term trends, or the absence thereof, and where possible correlates these to industrial operations in the vicinity.

The Celgar Pulp Company mill, located outside Castlegar, is the major industry of the immediate area and has been operational since 1961. Few structural changes or improvements in its process systems have been constructed in that time. A specialized scrubbing system, designed to reduce total reduced sulphur emissions from the recovery boiler, was installed in 1981. However, the contaminant loading of the incoming gas stream often exceeds the design capabilities of this system. This results in unacceptably high emissions of reduced sulphur compounds. The mill continues to operate under a ministerial variance order, which is in effect until 1991.

During most of the year the atmosphere appears to disperse the industrial emissions in this part of the Columbia River valley without immediate adverse affects on the local environment. However, certain weather conditions can severely restrict the dispersive capability of the receiving environment resulting in accumulations of pollutants.

This report presents data from 17 air quality monitoring stations. Three of these; Centennial Library, Castlegar airport, and Castlegar Regional Hospital, are operated by the Ministry of Environment and Parks. The others are operated by Cominco Ltd. Atmospheric data from Environment Canada Stations at Castlegar Airport and BCHPA (Hugh Keenleyside) dam are used in frequency analysis of weather types.

The suspended particulate data show no trends. The observed levels in the Castlegar area are generally within published provincial environmental objectives, however, exceedance events do occur and are most likely to occur in the winter months. These observed levels are slightly lower than those observed in Trail and an industrial area of Vancouver and are slightly higher than those observed in a residential area of Vancouver.

There were no dustfall samples gathered by the ministry which exceeded published environmental objectives. The observed lead and zinc content of the dustfall data is significantly lower than that observed in Trail.

Suspended particulate and dustfall data show similar seasonal patterns although this pattern is not strong.

Sulphation rates increase in the Columbia River valley between Trail and Castlegar in the winter months. This is assumed to indicate increased levels of ambient atmospheric sulphur and, furthermore, the source of this ambient sulphur is assumed to be industrial emissions.

It appears that this winter increase results from the decreased dispersive capability of the atmosphere. However, the available data are inadequate to address the question of the relative contribution of the two major sources, or the contribution of any minor sources, of atmospheric sulphur to this phenomenon.

Computer modelling of the emissions from the three major stacks of Cominco Ltd. operations at Trail indicates that under certain atmospheric conditions these emissions could impact the Castlegar area. Frequency analysis of the weather data indicates that the occurrence of such conditions increases in the winter, however the winds associated with their occurrence are distributed equally between northerly and southerly directions.

142 exceedance events above provincial environmental objective B (28 ug/m^3 for 1 hour) for ambient total reduced sulphur were recorded at the Castlegar Regional Hospital monitoring station in 1986. These events occurred over 49 non-consecutive days.

Computer modelling of the main stack emission plume of the Celgar Pulp Company mill indicates that under certain weather conditions the plume could impact Castlegar. Frequency analysis of the weather data indicate an increase in these weather conditions in the spring and summer. However the existing data are inadequate to eliminate the possibility that currently unmonitored, low volume sources also contribute significantly to such events. As well, these minor sources may cause exceedance events under atmospheric conditions which preclude the impact of the main stack emission plume on Castlegar.

Emission data submitted to the Ministry of Environment and Parks indicates that particulate and bivalent sulphur emissions from the mill are within permit limits.

The available ambient air quality, emission and weather data are inadequate to develop any concise emission/environment relationships.

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CASTLEGAR AIR QUALITY

A Compilation and Synopsis of Ambient Air Quality and Industrial Emissions Data

1975 -1986

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This report has been prepared by the British Columbia Ministry of Environment and Parks, Kootenay Regional Operations, to present air quality data gathered in Castlegar, B.C. during the period 1975-86 in a single, readily accessible document. This information will be of use to regulatory agencies, public groups, health officials and companies concerned with air quality in Castlegar. This report follows the Kootenay Air and Water Quality Study Phase I, Air Quality in Region C, the Nelson-Castlegar-Trail Area, completed in 1977.

The purpose of gathering ambient air quality data is to establish long term trends in the quality of the environment and to establish a data base with which to assess the effects of industrial operations on the environment. Stack emission data are obtained as an indicator of properly functioning industrial operations. Stack emission data also have some enforcement ramifications, since the discharge permit under which any industry operates specifies allowable discharge volume and quality limits for most major emission sources.

The purpose of this report is to present and discuss any changes which have occurred in the ambient air quality of Castlegar and to correlate these, where possible, to emission sources: the operation of the Celgar Pulp Company's mill near Castlegar or Cominco Ltd.'s smelter operations at Trail. The aspects of air quality examined here are total suspended particulate, dustfall, sulphation rate and total reduced sulphur.

To aid the reader in understanding the significance of the data, its presentation is preceded by some discussion of the processes utilized by the Celgar Pulp Company, the resulting emissions and the general behaviour of industrial emissions in the atmosphere within the context of the Castlegar situation. For similar information with respect to Cominco Ltd. operations at Trail the reader is referred to the Trail Air Quality report (White et al., 1986).

Introduction

In 1895, Castlegar, then known as Waterloo, was a mining town that boasted forty houses. In 1902 the Canadian Pacific Railway built a bridge at Castlegar and laid the railway to Trail. Castlegar has its roots as a transportation center and later as an industrial and distribution center. There is, has been and continues to be, an aspect of Castlegar as a "bedroom town for Cominco" as many of the residents of Castlegar work in Trail.

In 1959, Columbia Cellulose Co. started construction of its Celgar Pulp mill on the bank of the Columbia River 7 km. northwest of Castlegar. This mill started full operations in 1961, and was the first kraft mill built on inland waters in British Columbia. The mill has gone through several names and owners and is now owned by a consortium of Power Corp, Consolidated Bathurst and CITIC BC, the investment arm of the

Chinese government. It operates under the name of Celgar Pulp Company.

Currently, this mill produces in approximately 565 tonnes per day of pulp. This pulp can be fully bleached market pulp, semi-bleached kraft pulp or specialty pulp, made using specific amounts of chips from several tree species. The chips are either acquired from the adjoining sawmill, purchased on the open market or produced by chipping whole logs.

Celgar Pulp Company Process Description

This section introduces the major sources of emissions, and places those sources in the context of the whole operation. These are only the major sources; there are numerous smaller emission points, such as pressure relief valves, throughout the mill. The major emission source is the recovery boiler.

An overview of the kraft pulping process is presented in Figure 1. The following is a brief description of the process, highlighting the discharges to the atmosphere at each stage. This process consists of two cycles: the production of pulp and the recovery and restoration of the chemicals used in that production.

Chips and cooking liquor, an aqueous solution of sodium sulphide and sodium hydroxide, are fed continuously into the digester vessel. The pulp (digested chips) is discharged continuously from the bottom of the digester into the blowtank. The pulp is then washed free of entrained cooking liquor in the brown stock washers. The entrained cooking liquor is called "black liquor". The black liquor and the wash water are transferred to the weak black liquor storage tank. The pulp is pumped to the stock tank for storage prior to bleaching.

The weak black liquor which contains the chemical constituents of the process plus the dissolved non-cellulose portion of the wood, is concentrated in multiple effect evaporators to a concentration of approximately 50% solids. This strong black liquor is then used to collect the solid material captured from the recovery boiler flue gases by an electrostatic precipitator. It is then further concentrated by direct contact with hot flue gases in the cascade evaporator. At this point the black liquor is approximately 70% solids and can be burned in the recovery furnace. In the recovery boiler, the organic component of the black liquor burns producing heat, which is used to generate steam. The sulphur and sodium containing compounds undergo a series of chemical reactions forming hydrogen sulphide and sulphur dioxide. A molten mass of sodium carbonate and sodium sulphide falls to the base of the furnace and is known as "smelt."

The smelt flows into water in the smelt dissolving tank, and forms "green liquor." Slaked lime is added and the green liquor is clarified to form "white liquor."

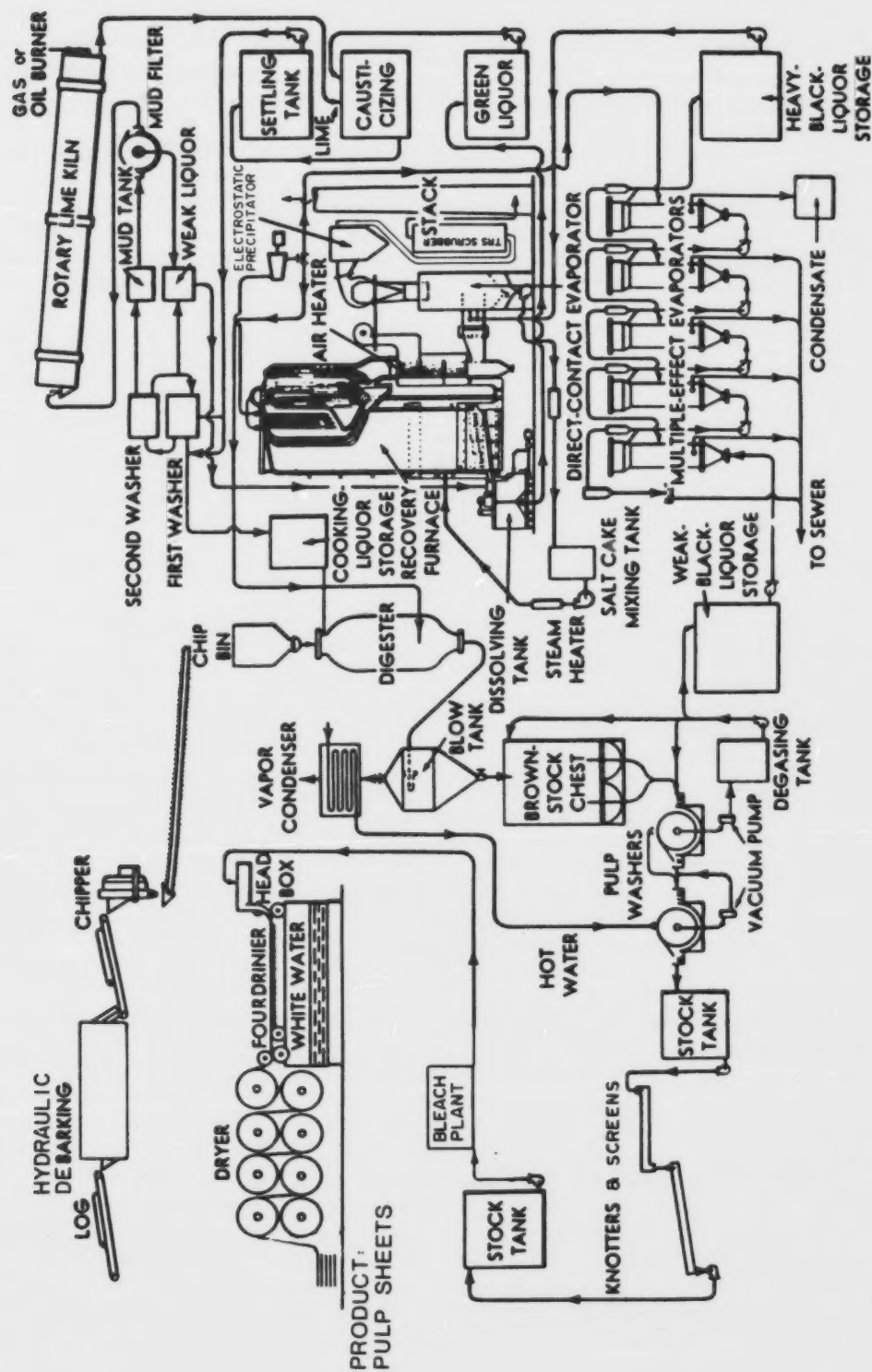
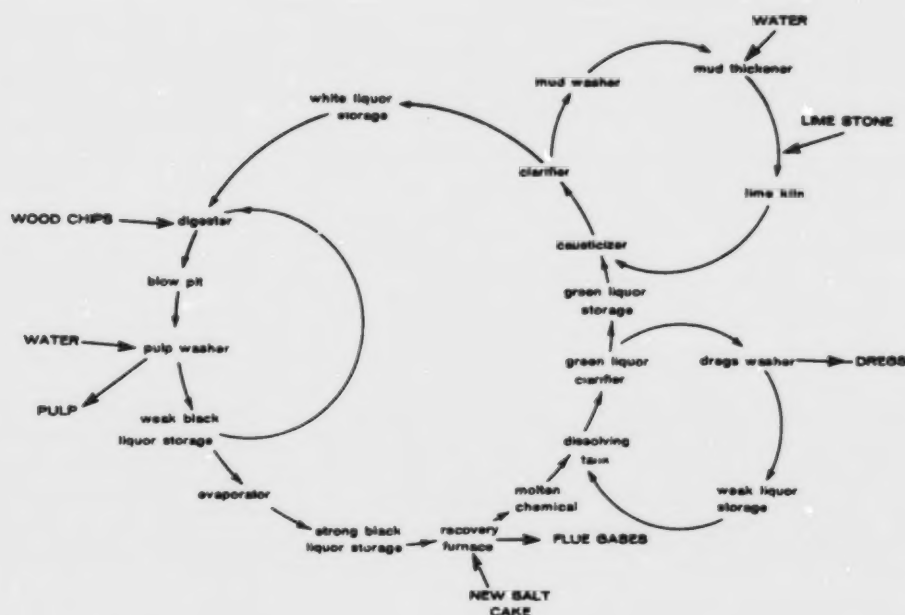


Figure 1: Flow diagram of the kraft pulping process

This recovery process is cyclical (Figure 2) with most of the chemicals reused many times. Significant losses occur during spills of pulping chemical and from carryover of chemical into the bleach plant.

After the pulp has reached the desired whiteness it is transformed into a continuous sheet, dried and packaged for market.



Major Emission Points

The exhaust

dimethyl sulphide (CH_3SCH_3) and dimethyl disulphide (CH_3SSCH_3). These are highly odorous gases which are detectable by the human nose in the parts per billion range.

The waste gases are passed through an electrostatic precipitator to remove particulates from the gas stream. A specialized scrubber has been installed downstream of this precipitator to reduce the emissions of sulphur gases to the atmosphere. In this scrubber, the waste gases pass through a dense alkaline water spray, among other things, which removes any residual particulate and SO_2 gas. Unfortunately this scrubber is often asked to function beyond its design capabilities - the contaminant loading of the gas flow is too high - with the result that odour producing gases continue to be emitted.

ii) Smelt Dissolving Tank Vent

The dissolving of the molten smelt in water results in the generation of large quantities of steam and particulate. The gases from this process are vented through the smelt dissolving tank vent, which is equipped with a scrubber to remove the particulate from the gas stream. Some reduced sulphur compounds may be generated depending on the pH of the scrubber water.

iii) Wood Burning Power Boilers

There are two wood waste/gas fired power boilers. No.1 Power Boiler is the larger of the two and operates continuously. The exhaust gases are treated by multicyclones to remove flyash. This boiler discharges through a common stack with the recovery boiler to use the buoyancy of the hotter gases to lift the cooler and moister recovery boiler flue gas higher into the atmosphere and increase the dispersion potential of the emission plume.

No. 2 Power Boiler is presently on standby most of the year due to reduced steam demand from the mill. Its emissions are also treated using multicyclones for flyash removal.

iv) Lime Kiln

This mill uses a long cylindrical rotating kiln for the conversion of lime mud (CaCO_3) to quick lime (CaO). The kiln is fired by natural gas or oil. The exhaust gases are treated using a wet scrubber for particulate removal.

The lime kiln is also used to incinerate non-condensed portions of the vapours from the chip steaming vessel, and from the continuous digesters, blowtank, digester flash tanks and multiple effects evaporators. The condensable portion is recycled with the liquor recovery system or sent to the sewer. The non-condensable portion of these gases contains concentrated sulphur compounds, and is collected and piped to the lime kiln for incineration. Disposing of these gases on this way avoids a potential air pollution problem and allows the sulphur portion of the gases to be recovered.

v) Miscellaneous Sources

The pulp mill has many storage tanks for various process liquids. These tanks must be vented to the atmosphere, however the discharge rates from such vents are generally small. The black liquor oxidation towers, in which weak black liquor is oxidized by aeration, are a more significant source of emissions.

vi) Bleach Plant

The emissions from the bleach plant are collected and vented through a single stack. At times of industrial malfunction in the plant, this emission can be tinted greenish-yellow due to excess chlorine, however under normal conditions this emission is mostly water vapour.

Industrial Emissions

This section will present some general information about the types of air quality parameters considered in this report and their behaviour in the atmosphere.

In urban/industrial situations it is very difficult to relate the ambient air quality of the environment to a particular emission source. This results from the nature of most contaminants and their behaviour in the atmosphere, and is compounded by the fact that there are often multiple sources of most contaminants.

For example, suspended particulate is defined as any airborne solid particle of a specific size range, and the sources of such particles can be any of a number of industrial emissions; such as car exhaust, road dust, the entrainment of soil particles by wind and so on. Once in the atmosphere such particles are carried by wind. Air masses mix so that at any specific time the contaminants measured in the air at one site could come from one or several emission sources. This relationship will be changing continuously, depending on the level of activity in the community and the climatic conditions.

Such non-specific contaminants as total suspended particulate or dustfall are often those that cause the most concern to the community at large. To assess the impact of any particular source, the contribution of its emissions relative to that of other sources must be calculated. The logistics of identifying each possible source and quantifying its contribution quickly become prohibitive.

Emissions of unusual contaminants by specialized industrial operations relate more directly to ambient levels. This is the case with respect to ambient hydrogen sulphide levels in Castlegar, as the major source of hydrogen sulphide is the kraft pulp mill operated by Celgar Pulp Company. Considering the type and volume of emissions from the Celgar Pulp Company mill operations and the lack of other comparable anthropogenic or natural sources in the area, common sense implies that the ambient levels of total reduced sulphur in the Castlegar area

must be a result of, or at least very strongly influenced by, the emissions of the pulp mill.

What follows is a short discussion of each of the air quality parameters discussed in this report. The effects, behaviour and sources of each are presented.

Total Suspended Particulate

These are small particles which can remain aloft for appreciable lengths of time and travel with the air currents (MacGill et al., 1956; US Department of Health, Education & Welfare, 1969).

They are of concern for a number of reasons.

Particles less than 10 microns in size can be drawn into human bronchial and nasal passages and those less than 2.5 microns in size can be drawn into the lungs (National Research Council of Canada, 1982).

High levels of total suspended particulate matter in the air will produce a visible haze, affecting the amount of sunlight reaching the ground.

Each particle can potentially form a condensation nucleus, leading to increased fog and mist formation under suitable atmospheric conditions of humidity and temperature. In turn, each particle provides a surface for reactions between chemically reactive emissions and atmospheric gases, for example, the conversion of sulphur dioxide to various sulphur acids. Such chemical activity would contribute to the degradation of any surfaces with which these particles make contact.

The sources of total suspended particulate in Castlegar are the Celgar Pulp Company power boiler, other industrial activities, car exhaust, road dust and re-entrainment of settled particles by the wind.

The mechanisms for its removal from the local atmosphere are:

i- wet deposition - via precipitation; the particles are removed from the atmosphere when they form condensation nuclei and are incorporated into the resulting precipitation or they are collected by falling precipitation, through contact;

ii - dispersal - being carried out of the area by air movement, and

iii - coagulation - if they make contact in the air particles may clump together eventually achieving a enough mass to settle as dustfall.

Dustfall

Dustfall is comprised of particles that settle out of the atmosphere under the influence of gravity. They are generally greater than 20 microns in diameter. The zone of greatest impact from a dustfall source is assumed to be within two kilometers of the source (MacGill et al., 1956; Stern, et al., 1973).

Dustfall is of concern because of its visibility (dirty cars and buildings), its effect on vegetation (it physically blocks sunlight and gas exchange by its presence on the leaves) and the possibility of soil contamination.

The sources of dustfall in Castlegar are fly ash from waste burning operations at the Weststar Sawmill (twice annually), Celgar Pulp Company mill operations, the operation of gravel pits and asphalt plants, and road dust.

The mechanisms for its removal from the atmosphere are settling out by gravity and being dispersed by winds greater than 10 kmh.

Sulphur Oxides

The only source of sulphur oxide emissions which can affect the air quality of the Castlegar is the Cominco Ltd. operation at Trail. The recovery boilers of most kraft pulp mills emit SO_2 gas in amounts similar to their emissions of H_2S , however the recovery boiler scrubber at the Celgar Pulp Company mill utilizes an alkaline spray which eliminates any SO_2 from the gas stream.

The bulk of the sulphur emissions from the Cominco Ltd. plants are in the form of gaseous sulphur dioxide. In the atmosphere this gas undergoes chemical reduction process to form sulphur trioxide and various sulphur acids. For a more complete discussion of the air quality and industrial emissions in the Trail area the reader is referred to White et al., 1986.

The natural mechanisms for sulphur removal from the atmosphere are wet deposition and dispersion.

Total Reduced Sulphur Gases

Kraft pulp mills emit a number of sulphur compounds: hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulphide (CH_3SCH_3), dimethyl disulphide (CH_3SSCH_3) and oxides of sulphur (SO_x) (U.S. Environmental Protection Agency, 1976; Environment Canada, 1975). These are highly odorous compounds to which the human nose is extremely sensitive. Hydrogen sulphide produces the characteristic rotten egg odour of pulp mill emissions.

H_2S produces an obnoxious smell at levels far below any possible health hazard. It produces an unpleasant smell at between 10 - 14 ug/m^3 (0.01-0.02 PPM), while the first signs of discomfort (head aches and dizziness) occur at 140 ug/m^3 (0.2 PPM) and the first health effects (eye irritation) at 14 000 ug/m^3 (approx. 20 PPM). H_2S can be lethal when it occurs in concentrations greater than 500 000 ug/m^3 (approx. 700 PPM). (Minor, 1969; National Research Council of Canada, 1981)

During 1986, there were a total of 13 readings greater than 100 ug/m^3 recorded at the Castlegar Regional Hospital station, of which 6 occurred in a single exceedance event, which occurred on March 19. The highest hourly level recorded was 354 ug/m^3 . There were 49 days (142 hourly readings) on which recorded levels

exceeded the provincial air quality objective level B (28 mg/m^3). In most cases these events were of less than 5 hours duration, however there was one event which persisted for 20 hours, through the night of January 20/21.

In the atmosphere the residence time of H_2S is thought to be generally less than one day (National Research Council of Canada, 1981, Environment Canada, 1980), after which it will have been chemically oxidized to one of the sulphur oxides. This residence time will vary with atmospheric conditions and the presence of other chemical reagents in the atmosphere.

The natural mechanisms for the removal of reduced sulphur compounds from the atmosphere are dispersion and chemical transformation.

Wet and dry deposition (incorporation into precipitation and direct reaction with a substrate), while technically possible, are thought to be negligible under normal atmospheric conditions (National Research Council of Canada, 1981).

Summary of Emission Characteristics

Each of the preceding contaminants has a specific particle or molecule size or size range and therefore behaves differently in the atmosphere. A summary of some of the atmospheric behavioural properties of particles in several size ranges is given in Table 1, and examples of the size ranges of some common substances is given in Fig. 3.

Table 1: Theoretical Particle Settling Velocities, Potential Time Airborne and Travel Potential

Size	Density	Settling Velocity	Settling Velocity	Time to Fall	Travel
microns	gm/cm^3	m/sec	kmh	Stack Height hr (min)	Potential km (m)
1	5	0.000122	0.0004	277.8	1611.2
	10	0.0003	0.001	113.0	665.4
10	5	0.0122	0.0439	2.78	16.12
	10	0.030	0.01	1.13	6.55
100	5	0.98	3.5	0.0346 (2.1)	0.20 (200)
	10	1.83	6.6	0.0185 (1.1)	0.107 (107)
1000	5	11.58	41.7	0.0029 (0.17)	0.017 (17)
	10	16.76	60.3	0.002 (0.12)	0.012 (12)
(1 mm)					

Notes:

- i- these calculations assume no continued upward motion upon exit from the stack.
 - ii- travel potential is calculated using the 1975-85 average wind at Cominco Ltd. administration building.
 - iii- stack height used is 110 m. This is the average of the height of the three main stacks at Cominco Ltd. operations at Trail. The Celgar Pulp Company main stack is 76.2 m high.
- sources: Perry et al, 1963, Cominco Ltd, 1986
(from White, et al., 1986)

CHARACTERISTICS OF PARTICLES AND PARTICLE DISPERSOIDS

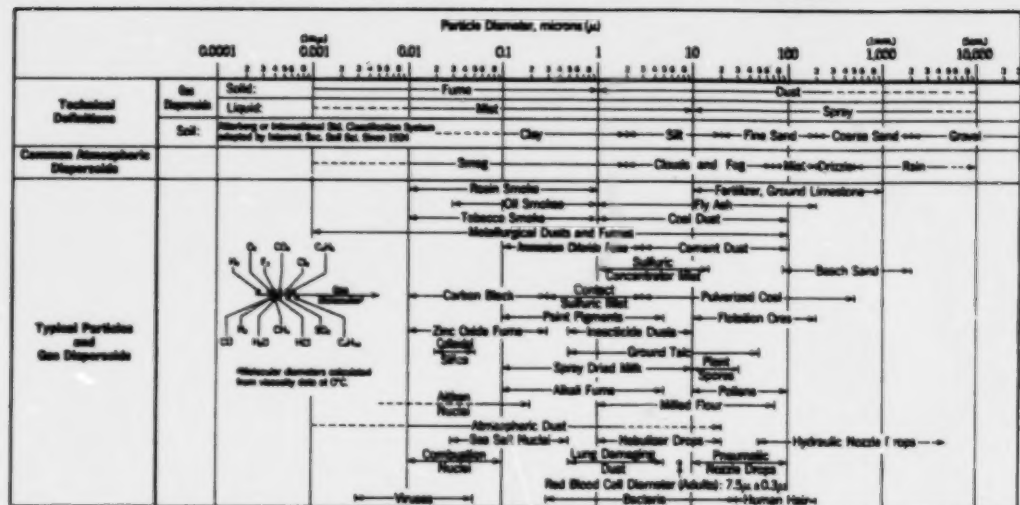


Figure 3: Sizes of some common substances (Perry et al., 1963)

Influence of Physical Geography

Physical geography and climate interact to influence the local weather patterns, and hence, the dispersive capability of the local atmosphere and the effect of industrial emissions on the surrounding environment.

Castlegar is situated on the banks of the Columbia River at the confluence of the Columbia and Kootenay Rivers (Figure 4). The Celgar Pulp Company mill is situated 6 kilometres (km) upstream of the town near the Hugh Keenleyside dam. The elevation of the valley bottom is 400 - 450 metres (m) and the elevation of the surrounding ridges is 1200-1500 m with peaks to 2100-2400 m. The Columbia River valley is generally steep sided and tends north/south. At Castlegar the Columbia River valley turns 90° for approximately 20 km. before returning to this north/south alignment. Also at Castlegar the Pass Creek and Kootenay River valleys enter the main valley. The deep valley of the Columbia River provides a channel for the movement of air through this terrain.

The climate of the Columbia region is described as semi-arid with warm summers and cold winters (Chilton, 1981). Total precipitation of stations in the Castlegar area is given in Table 2. Precipitation occurs throughout the year with a maximum in the winter and a minimum in the late summer/early fall. Temperatures vary from an average daily minimum of -3.8 °C in January to a average daily maximum of 20.4 °C in July.

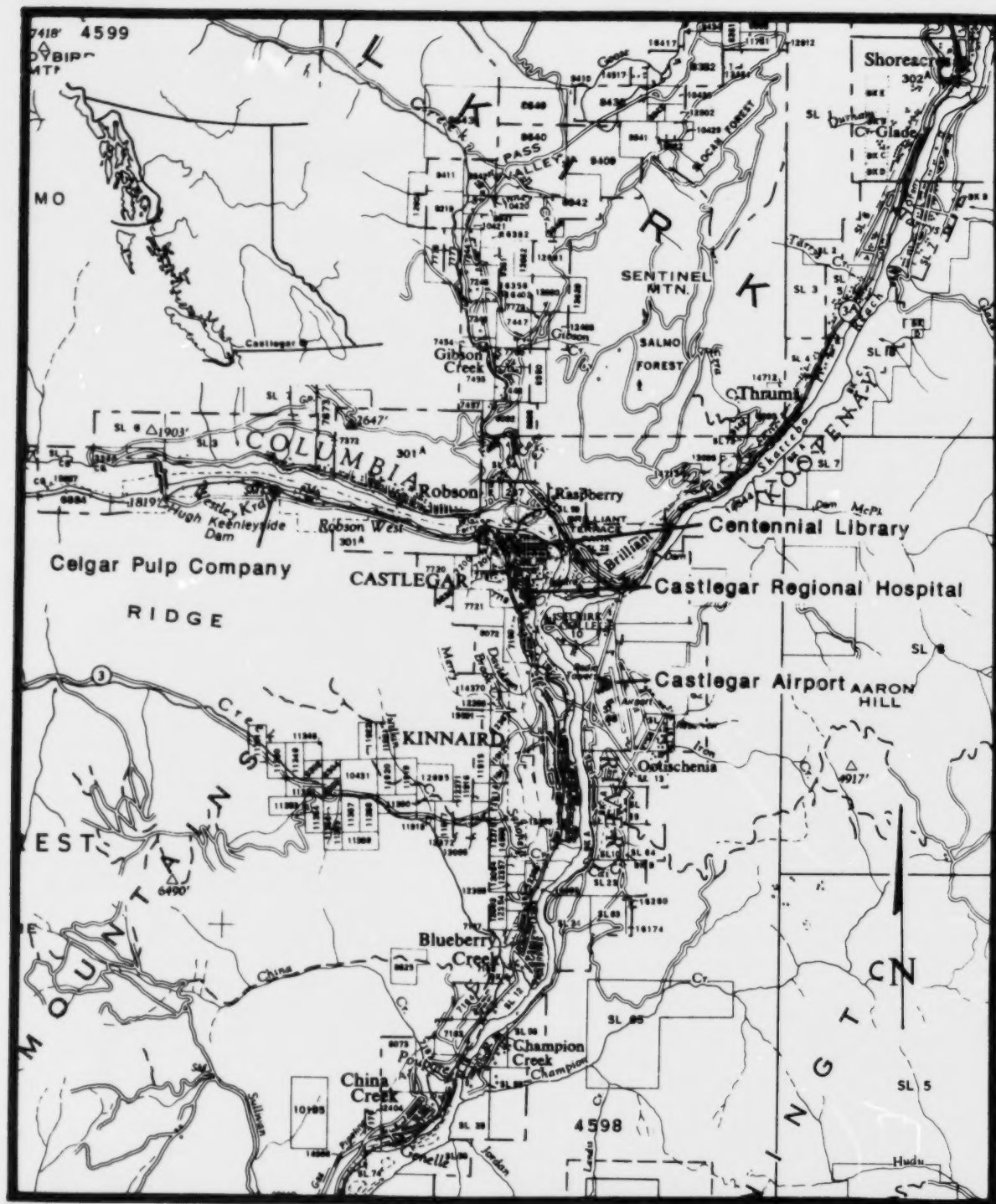


Figure 4: Castlegar, B.C. showing the location of some air monitoring stations (Scale - 1:250 000)

Table 2: Normal precipitation and temperature for stations near Castlegar

Station	Elevation (m)	Total Precipitation (mm)												Total
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
Castlegar														
Airport	495	84.5	63.4	58.0	44.0	53.8	62.9	35.6	45.7	36.4	54.0	80.9	99.8	719.0
Castlegar														
BCHPA Dam	475	79.7	42.4	40.4	35.6	44.1	53.1	31.3	45.5	34.3	39.0	56.3	64.0	565.7
Robson	442	98.37	56.5	58.1	37.1	47.8	56.6	35.6	41.2	38.0	53.3	73.0	100.7	696.2
Temperature (°C)														Average
Castlegar														
Airport	495	-3.8	-0.8	2.7	8.1	13.2	16.9	20.3	19.7	14.4	8.1	1.7	-1.9	8.2
Castlegar														
BCHPA Dam	475	-2.7	0.0	3.3	8.3	13.1	16.8	20.4	19.6	14.8	8.4	2.7	-0.8	8.7
Robson	442	-3.1	-0.1	3.3	8.3	12.9	16.4	19.6	18.9	14.2	8.2	2.2	-1.3	8.3

source: Environment Canada, 1981

In the context of air quality - the impact of emissions on the surrounding environment - the major controlling factor is the weather. The weather is the transportation mechanism which carries the pollutants to their point of impact. In general, contaminants are removed from the air via wet deposition (incorporated into rain or snow), dry deposition (sedimentation, chemical reaction with a surface or direct uptake by plants) or diffused and dispersed by air movement.

Contaminant removal by precipitation takes two forms. Contaminants are collected when contacted by falling rain or snow and carried to the ground. This mechanism clears both particulate and gaseous pollutants. Also, airborne particulate matter may form condensation nuclei around which water droplets form, and the contaminants are carried to the ground by the resulting precipitation. Gaseous pollutants may condense onto these particles in addition to water vapour.

Diffusion and dispersion result from the movement of air masses. This movement can result from regional weather, a Pacific storm moving through, or a localized weather pattern.

The effects of valley geography on local weather patterns in general are to reduce the magnitude of the regional weather effects in the valley bottom. There is a general reduction in wind strength caused by the physical nature of the valley, which tends to isolate the valley bottom from the upper atmosphere. Winds that do occur tend to be channelled within the valley, restricting pollutant dispersion to two directions. There is an increased frequency of long term (several day) inversion events, which further isolate the atmosphere in the valley from the upper atmospheric weather.

An inversion is the situation where air temperature increases with elevation. Under normal conditions, the opposite would be true. An inversion restricts the vertical movement of air through the effects of temperature and pressure on volume of a gas. The effect of an inversion is to isolate the air below the inversion from the air above it. Generally surface level winds result from high level regional winds. Therefore, an inversion will produce a calm, stable air mass below it, restricting the dispersive capability of that air mass.

Inversions can be ground based - the situation shown as "before sunrise" (Fig. 5) - or elevated - "soon after sunrise" (Fig. 5).

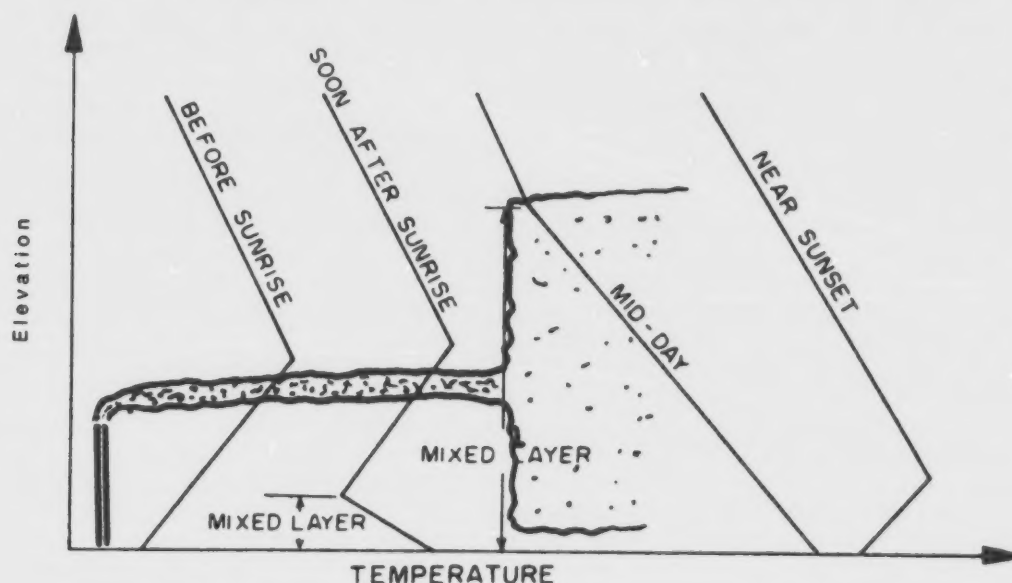


Figure 5: A representation of temperature distribution at several times during the day (Atmospheric Environment Service, 1979)

During a ground based inversion the plume will rise to an equilibrium level within the inversion and collect. While the inversion exists these emissions will be held away from ground level. The radiation of the sun is the force which works to break up most inversions. Solar radiation heats the ground which in turn heats the air immediately above it. As this air is heated it tends to rise which causes cooler air to flow in underneath, to be heated in its turn. The result of this is a churning of the air - the formation of a mixed layer. The strength and depth of this mixed layer depends on the strength of the sun's rays reaching the ground. When the developing mixed layer reaches the equilibrium elevation of the plume there may be a fumigation event, as the collected emissions can now mix to

ground level. This may give rise to short intense peaks of contaminant levels.

During an elevated inversion, with a mixed layer beneath it, the plume may be trapped under the inversion layer. The pollutant will disperse within the mixed layer at a rate dependant on the stability of the mixed layer and the transport wind speed within the mixed layer.

The effect of a specific inversion event on a specific plume will depend on the strength and elevation of the inversion and the characteristics of the plume in question. For example, a computer model of the main stack plume of the Celgar Pulp Company mill indicates that the equilibrium plume height is in the order of 250-300 m. If an elevated inversion layer developed at 200 m, this would isolate the main plume from the ground while trapping the low level emissions beneath it. In such a case the mill emissions within the main stack plume would not impact the ground while the emissions of all the low level sources, the escape valves on various tanks etc., would be emitted into an effectively small air mass and could produce a period of low air quality.

An advection inversion is caused when a warm mass of air overrides a layer of cool air. This situation occurs in Columbia River valley during winter when a warm Pacific storm moves over southern B.C. trapping the cool air in the valley. Given the reduced insolation and the probable increase in cloud cover during winter, such events tend to be multi-day events causing a general buildup of contaminants within the entire valley.

All inversions will be enhanced by the valley terrain. At night cool air will tend to flow down the valley sides and pool in the valley bottom (Fig. 6).

Local winds are also strongly influenced by the terrain. In the Castlegar area winds predominantly blow up or down the valley (Figure 7) with a great deal of daily and cross-valley variation.

The strength of the wind into which the plume is emitted has a significant effect on the potential impact of the plume. Strong winds have the effect of diluting the plume immediately upon its emission. The air is moving over the mouth of the stack and the plume is emitted into an effectively larger volume of air than in a low wind situation. In addition to this, a strong wind tends to limit the plume rise. In this situation the main plume will impact the ground closer to the mill, although its effect will be decreased due to the initial dilution.

A low wind results in the maximum concentrations at the stack mouth, while allowing maximum plume rise and minimal diffusion. The source of diffusion is the natural turbulence resulting from air motion. The plume will impact the ground relatively farther from the mill but its impact could be greater. In this situation the effect of the minor low level emission sources will be greater in the vicinity of the mill. There will be minimal diffusion as the fumes of these sources drift over the terrain. Under these conditions, a deterioration in the air

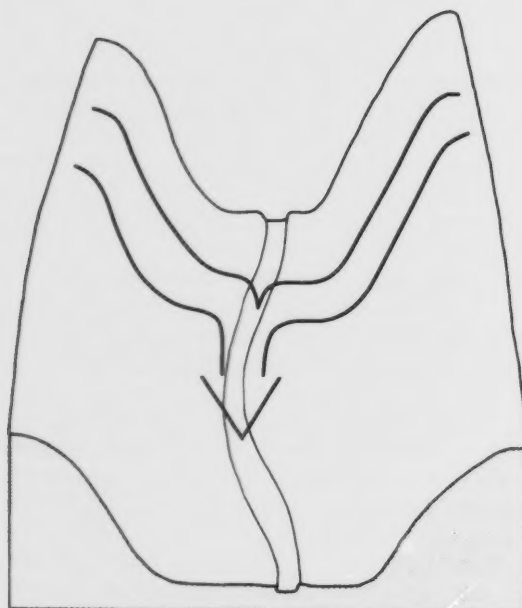


Figure 6: Nocturnal valley circulation (Atmospheric Environment Service, 1979)

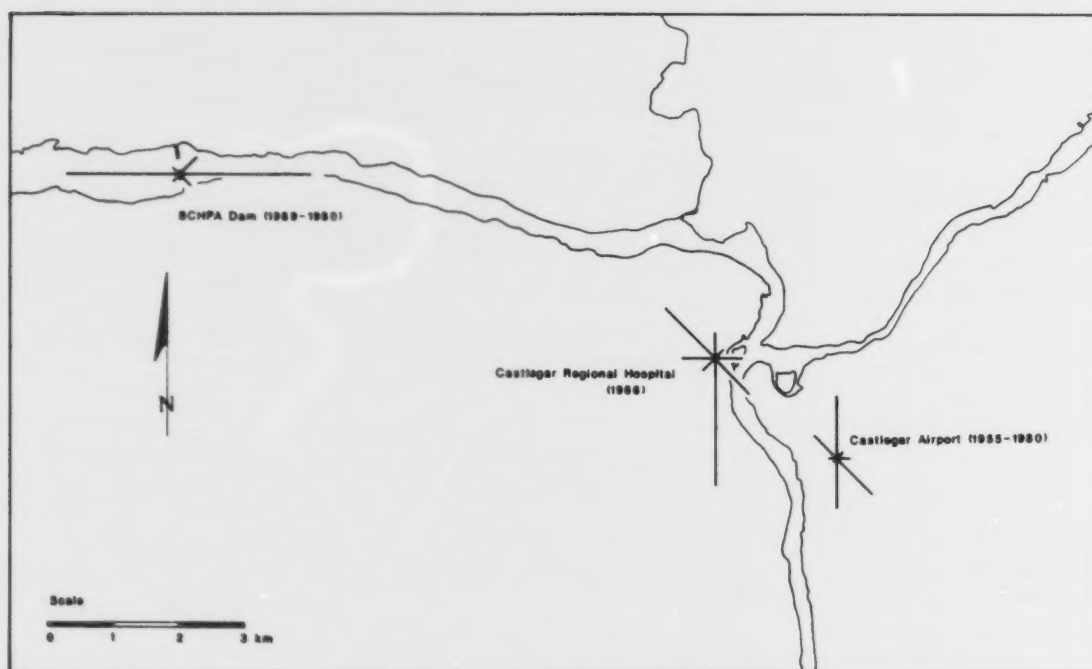


Figure 7: Wind roses showing relative occurrence by direction for three stations in the Castlegar area (numbers in brackets indicate period of record).

quality close to the mill is more likely to be due to the minor sources than the major source - the recovery boiler plume.

Another cause of localized high ambient pollutant levels would be the direct impact of the plume with rising terrain (i.e. the valley walls). This could result in short term but high ambient levels of total reduced sulphur gas in the Pass Creek valley, for example.

Each of the situations in the preceding discussion is also influenced by a seasonal pattern. This pattern has its own effects on the dispersive capability of the atmosphere and the relative impacts of the various industrial emissions in the Columbia River valley.

In the winter, the frequency of winds from the south increases (Figure 8). Concurrently, such factors as sun height above the horizon and cloud cover will reduce the insolation at ground level, increasing the likelihood of inversion events. Weather data from Castlegar Airport show that the occurrence of reduced visibility conditions increase in the winter and usually occur in calm air or in conjunction with winds from the south (Table 3).

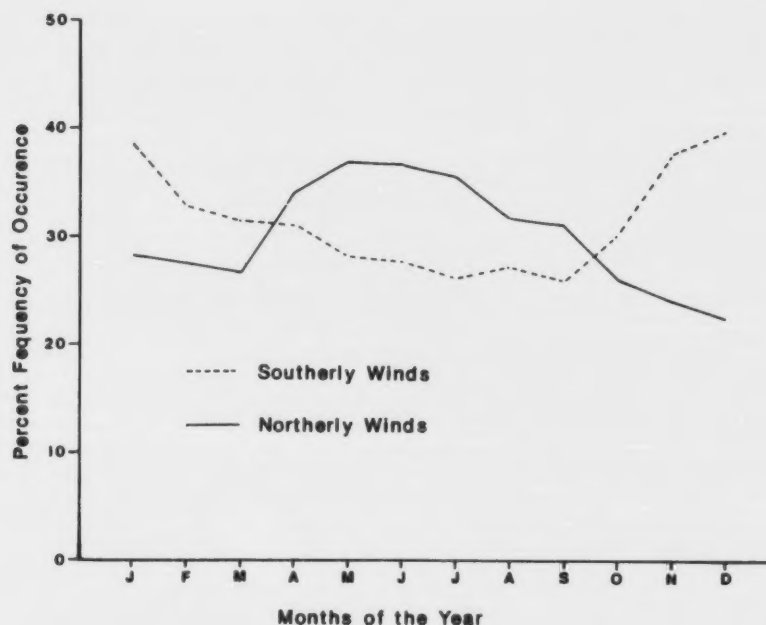


Figure 8: Seasonal change in wind direction at Castlegar airport (from Environment Canada, 1981)

In addition to this, there is an increase in the occurrence of fog and smoke at the Castlegar Airport (Table 4).

Using this data alone, one would expect that the reduced air quality in the Columbia River valley north of Trail during the winter results from Cominco Ltd.'s emissions. Indeed, weather

Table 3: Percent frequency of visibility observations by wind direction at Castlegar Airport.

Reduced Visibility (less than 10 km)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
in calm air	14.9	14.2	8.6	2.3	1.7	1.9	0.9	1.7	4.9	9.8	12.8	16.7
with northerly winds	7.4	6.7	3.8	1.1	1.4	0.8	0.4	0.8	1.7	3.7	2.9	4.9
with southerly winds	20.7	14.5	6.8	2.5	1.5	1.6	1.0	1.5	4.8	11.7	17.6	24.1
Unlimited Visibility from Environment Canada, 1985	56.7	64.6	80.8	93.9	95.4	95.6	97.7	96.0	88.6	74.7	66.7	54.1

Table 4: Mean number of days with reduced visibility due to fog and smoke at Castlegar Airport.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fog	4	6	4	1	1	1	1	2	6	10	5	5
Smoke	19	18	12	5	5	5	3	4	9	15	18	20

Notes:

i - averages are calculated for the period 1965 - 1985.

ii - "Smoke or Haze: a day when the visibility is restricted to 10 km or less because small dry particles are suspended in the air. These particles must be sufficiently numerous to give the air a greenish-yellow, light-greyish or bluish hue for smoke, or a milky or pearly hue for haze."

iii - "Fog: a day when fog occurs, i.e., when the horizontal visibility is restricted to less than 1 km because very small water droplets are suspended in the air."
Environment Canada, 1985

observers at the Castlegar Airport maintain that much of the decreased visibility experienced during the winter months is a result of the smelter plume drifting up the valley from Trail (T. Wilson, Environment Canada, Pers. Comm., 1987). However, as we shall see, we cannot justify or eliminate such a conclusion using the air quality data currently available.

Environmental Objectives/Discharge Permits

The Ministry of Environment published "Pollution Control Objectives for the Forest Products Industry of British Columbia 1977." The objectives of relevance to Castlegar are presented in Table 5.

These objectives are guidelines only; they are not legally binding on either the government or any company. The regulations that control ambient air quality are permits issued under the authority of the Waste Management Act. These are legal documents specific to the operation in question which identify emission points of concern, designate discharge volumes and quality for each, and set out any discharge and/or ambient monitoring requirements. Only contaminants which are relevant to the

Table 5: Ambient Air Quality Objectives

Parameter	Units	A	Level B
Total Reduced Sulphur(TRS)			
compounds measured as H ₂ S			
24 hour concentration	ug/m ³	3	6
1 hour concentration	ug/m ³	7	28
Sulphur Dioxide			
annual arithmetic mean	ug/m ³	25	50
24 hour concentration	ug/m ³	160	260
1 hour concentration	ug/m ³	450	900
Total Dustfall			
Residential	mg/dm ² /day	1.75	1.75
Other	mg/dm ₂ /day	2.90	2.90
Suspended Particulate			
annual geometric mean	ug/m ³	60	70
24 hour concentration	ug/m ³	150	200

Notes:

"The aim of these objectives is to protect the quality of British Columbia's environment for the benefit of present and future citizens of the Province and Canada. The objectives provide for the use of the environment's assimilative capacity within limits which do not lead to unacceptable conditions. ... The Objectives are intended to apply Province-wide and are to be considered as minimum levels of performance. However, where sensitive environmental situations exist, the Director of Pollution Control may apply more stringent requirements. Conversely, less stringent requirements may be allowed where it can be shown that unacceptable deleterious changes will not follow."

(Ministry of Environment, 1977)

discharging processes are specified. The purpose of setting specified contaminant loading levels is to maintain acceptable ambient air quality levels. The contaminant loading levels are established after considering the discharge volume, the anticipated operating schedule of each stack and the total emissions discharged into the receiving environment.

Exceeding these permit levels means the company may be liable for prosecution. Such prosecution will not normally take place in the event of equipment or operational failure, provided that the procedures of notification and rectification are followed.

The permit covering the Celgar Pulp Company operations is PA-3080. The discharge limits specified in this permit are given in Table 6.

The Minister of Environment and Parks can issue a variance under the Waste Management Act for the reason of unfavourable economic conditions. This document may specify new levels of

Table 6: Permit discharge limits specified for the Celgar Pulp Company Mill.

Emission Point	Contaminant	Units	Daily Average Concentration	Maximum Concentration
Recovery Boiler	bivalent sulphur compounds	PPM	26	52
	particulate	ug/m ³	530	
#1 Power Boiler	particulate	ug/m ³	530	
#2 Power Boiler	particulate	ug/m ³	469	690
Lime Kiln	particulate	ug/m ³	460	690
Dissolving Tank	bivalent sulphur compounds	kg/ADUt	0.4	0.6
All sources of the non-condensable gas incineration system	bivalent sulphur compounds	kg/ADUt	0.35	0.75
Bleach and Chemical Plant Stacks	Cl ₂ and ClO ₂	PPM	0.1	0.1

Note: kg/ADUt = kilograms per air dried unbleached metric ton of pulp produced

discharge and contaminant loading for specific stacks, and normally would be in effect for a designated period of time. Such a variance is in effect for Celgar Pulp Company and will continue until June 30, 1991.

Celgar Pulp Company's variance specifies ambient TRS levels that are not to be exceeded at the Castlegar Hospital monitoring station. This monitoring data must be telemetered to the mill and used as appropriate to control emissions levels. These ambient specifications take precedence over the stack emission levels of bivalent sulphur compounds specified in the Celgar Pulp Company's permit.

The variance specified levels are as follows: prior to June 30, 1987 the maximum hourly TRS concentrations are not to exceed 110 ug/m³; during the period July 1, 1987 to June 30, 1991 they are not to exceed 70 ug/m³. This variance also specifies improvements to be made to certain existing emission control mechanisms, research to be carried out regarding potential improvements to other emission control mechanisms and a schedule under which this work is to be carried out.

The Ministry is currently examining the implications of total reduced sulphur emissions and their effect on ambient air quality preparatory to revising the existing ambient air quality criteria. These objectives should be complete by the expiry of the variance and may be used to revise Permit 3080 at that time.

Methods

Currently, the Ministry of Environment and Parks operates ambient air quality monitoring stations on the roofs of the library in Castlegar and the Castlegar Regional Hospital. The data types gathered at the library site are sulphation rate and

dustfall, both collected monthly, and total suspended particulate, collected every six days. Ambient TRS and weather data, both sampled continuously, are collected at the hospital site. Data has been gathered at other sites in the past, i.e. TSP at the hospital and sulphation rate and dustfall at the airport, however this data collection has been discontinued. Cominco Ltd. has gathered data at sites throughout the valley and has generously made this data available for this report. Some of this data collection has also been discontinued.

The Ministry of Environment and Parks' samples are collected by Kootenay Region Waste Management staff and the laboratory analyses are done by the B.C. Environmental Laboratory, 3650 Westbrook Mall, Vancouver, B.C. Cominco Ltd. samples are collected by the staff of Cominco Ltd.'s environmental control group and laboratory analyses are done at their facilities in Trail. The location some of the sampling sites referred to in this report are located in Fig. 4 and the location of the others is given in the phase I report (Ministry of Environment, 1977). Some geographic characteristics of each site are given in Table 7.

Summaries of the collection and analysis methods employed in this program and discussion of some of the pertinent characteristics of the resulting data are presented below. For more detailed information please refer to the following manuals:

- i) McQuaker, N.R. 1983. A Laboratory Manual for the Chemical Analysis of Ambient Air, Emissions, Precipitation, Soil and Vegetation.
- ii) Sandberg, D.K. 1979. A Manual of Field Procedures for Integrated Ambient Air Sampling.
- iii) Sandberg, D.K. 1979. A Manual of Field Procedures for Integrated Stationary Source Air Emission Sampling.

These manuals are the reference manuals used by the Ministry of Environment and Parks in its own collection and analysis and when approving permittee methods. The manuals are available for viewing at any B.C. Ministry of Environment and Parks Waste Management office.

Total Suspended Particulate

Suspended particulate samples are collected by filtering a known volume of air through a pre-weighed filter. The filter head is protected and positioned such that the sampled air must travel upwards before passing through the filter thereby ensuring that the sample is composed of airborne, as opposed to settling, material. After the 24 hour sample run, the filter is re-weighed and the difference is the total suspended particulate. Samples are collected every six days in accordance with the National Air

Table 7: Geographical Characteristics of Air Monitoring Stations in the Columbia River valley near Castlegar and Trail.

Station	Distance from Pulp Mill (km- south)	Elevation of Collection Site (m)	Height above Ground (m)	Notes
Centennial Library	4.7	440	5	MoEP stn.; on roof of library
Castlegar Airport	8.8	495	7	MoEP stn.; on roof of Adastra hangar
Castlegar Airport	8.8	495/480	7/2	Cominco stn. - see note iii)
Castlegar Hospital	6.1	450	15	MoEP stn.; on roof of Castlegar Regional Hospital
Blueberry Creek	14.3	472	2	Cominco stn.
China Creek	19.2	487	2	Cominco stn.
Genelle	20.2	426	2	Cominco stn.
Birchbank	23.7	533	2	Cominco stn.; in rural farm yard
Birchbank Golf Course	25.0	481	2	Cominco stn.
Oasis	28.7	549	2	Cominco stn.
Rivervale	29.6	411	2	Cominco stn.
Tadanac (Nurseries)	31.8	441	2	Cominco stn.
WKP & L Bldg.	33.4	450	38	Cominco stn.; on roof of WKP & L bldg.
Glenmerry	35.9	441	2	Cominco stn.; in public works yard
Pollution Centre	37.9	430	5	Cominco stn.; on roof of shopping centre
Columbia Gardens	42.7	436	2	Cominco stn.
Waneta	47.9	426	2	Cominco stn.; near US border

Notes:

- i) The elevation of the Celgar Pulp Company mill site is 427 m and the recovery boiler stack is 74 m high.
- ii) The elevation of Cominco Ltd. smelter operations is approximately 450 m and the average height of the three main stacks is 110 m.
- iii) The Cominco Ltd. Castlegar airport station was moved from the roof of the Adastra Air hangar to ground level near the fuel pumps in late 1979 (J. McCunn, Cominco Ltd., pers. comm. 1987).

Pollution Sampling Network Schedule. The results are presented in $\mu\text{g}/\text{m}^3$.

A subsample of the filter is then acid digested and analyzed for metal content, where such analysis is requested.

The Ministry of Environment and Parks uses the same procedure as described for dustfall in such analyses.

Dustfall

Dustfall samples are collected monthly using a straight sided open canister, initially half full of water. Antifreeze is added to this water in the winter and an algicide in the summer. The site is checked as required to prevent the canister from

overflowing or going dry. These canisters are set out according to government guidelines specifying clearance and exposure limits, and are left for approximately 30 days. The position of each canister is maintained through consecutive samples at each site.

The choice of site for the collection canister is critical in dustfall analysis. Such factors as distance from roads and height above the ground can have a significant impact on the levels of dustfall recorded. Ground dust, picked up by the wind, will not carry to any significant heights.

The Ministry of Environment and Parks separates each sample into a soluble and insoluble fraction by filtration. Total dustfall is the sum of both fractions. The Ministry conducts further analysis for metal content on each fraction using acid digestion followed by analysis in an "inductively coupled plasma atomic emission spectrometer." This entails heating the sample to plasma temperatures and recording the strength and wavelengths of emitted light. Each element will emit light of a characteristic wavelength under these conditions and the amount of light emitted will be proportional to the amount of the element present.

Results are expressed as $\text{mg}/\text{dm}^2/\text{day}$. All the data presented here have undergone conversion from other units (i.e. $\text{ton}/\text{mi}^2/\text{month}$) for some portion of the data set.

Sulphation Rate

These data are collected by exposing plates of collection medium for a period of approximately thirty days. The plates are set out in an inverted position to avoid contamination by particulate matter. The collection medium is lead oxide. Reaction and absorption of the gases occurs at the plate surface. Lead oxide will react with various sulphur oxides and hydrogen sulphide with similar rates and efficiency, but there is little evidence that it reacts with methyl mercaptans or methyl sulfides (N. McQuaker, Environmental Laboratories, pers. comm., 1987). The criteria used in choice of site for these plates are similar to those used for positioning dustfall canisters, with the added concern that there be no furnace or incineration flues nearby (Leung and Manna, 1984). The resulting data present a cumulative measure of gaseous atmospheric sulphur. The results are expressed in $\text{mg}/\text{dm}^2/\text{day}$.

The rate and efficiency of collection of the sulphur gases varies with such atmospheric factors as wind speed, temperature and humidity. There has been no work undertaken to assess exactly what compounds are collected and the relative rate of collection. With respect to atmospheric SO_2 , these results are thought to be reliable to within 25% (Lynch et al., 1978). The value of these data is as an indicator of long term trends and/or major fluctuations in ambient concentrations of sulphurous gases, rather than as a quantitative measure of atmospheric sulphur.

Total Reduced Sulphur Gas

The Ministry of Environment and Parks uses a variant of the pulsed fluorescent continuous SO₂ analyzer to measure the instantaneous ambient levels of total reduced sulphur gas. The incoming sample is first scrubbed of any gaseous SO₂, then all the remaining sulphur gases are then chemically converted to SO₂, and the sample is analyzed for SO₂ concentration. The analysis is based on the principle that SO₂ molecules exposed to ultra-violet radiation emit fluorescent light in amounts proportional to the amount of SO₂ present. The analyzer operates continuously and the results are reported as one hour averages of micrograms of total reduced sulphur compounds per cubic metre of air sampled. The system has an internal mechanism to check recorded zero levels and is manually checked against known concentrations of SO₂. An audit of the analyzer, conducted by B.C. Environmental Laboratory staff, is done on a bimonthly basis. The Ministry of Environment and Parks uses a Teco 43 Pulsed Fluorescent SO₂ Analyzer.

The analyzer at Castlegar Hospital is coupled directly to the recovery boiler control room at the Celgar Pulp Company mill. This allows the operators to respond to any increase in ambient total reduced sulphur gas levels which exceed the terms of the Variance. The response entails increasing the flow of air and decreasing the flow of black liquor into the recovery boiler, which reduces the production of reduced sulphur compounds.

Emission Sampling

The emission data used in this report is a measure of the total reduced sulphur loading of the exhaust gases of the recovery boiler stack. The stack gases downstream of the final scrubber are analyzed using gas chromatography. The instrument gathers and analyses a discrete sample every 10-12 minutes, resulting in a total of approximately 140 per day. The sample is injected into a carrier (an inert gas) which then passes through a stationary column. The various compounds of the sample pass through the column at different rates and are separated from one another. The amount of each compound is measured as it exits the column and the time of occurrence of the peak concentration serves to identify the compound. Such an apparatus must be calibrated for the type of compounds expected and the likely concentrations of the compounds. In this case the instrument is adjusted to be accurate when total reduced sulphur gas concentrations are in the 50 PPM range.

As the accuracy of the instrument decreases above 100 PPM, levels above 150 PPM are recorded simply as >150 PPM. If there are more than 10 readings >150 PPM during a day no daily average is calculated for that day. Ministry of Environment and Parks stack samples have recorded emission levels of 655 PPM (October 11, 1984) and 283 PPM (June 5, 1985) using 1 hour composite sampling techniques.

Under the terms of its operating permit Celgar Pulp Company is required to sample and report its emissions of specific parameters from a number of stacks within its operation. These data are inadequate for the purposes correlating emissions to ambient levels and are not used in this report.

Data Analysis

This report presents ambient air and emissions data currently available and discusses some of the more obvious ramifications of the data with respect to air quality. Due to the nature of the data, analysis has been limited to graphical presentation. These data are not suitable for most types of statistical analysis nor would the use of such analysis aid in their interpretation to the anticipated audience.

Computer modelling of the major emission sources has been used to identify some possibilities of the causes of the air quality phenomena discussed in this report. This model has some limitations which must be understood when interpreting the results. The model used here assumes that the plume is emitted over generally flat terrain, and since that is not the case, the models predicted ambient impacts of the plumes are likely low. In the confines of the Columbia River valley the plume is being emitted into a smaller volume of air than the model is using for its calculations, and hence the predicted values of ambient concentrations of gaseous pollutants are likely lower than those which actually occur. The model used was the PTDIS (Version 78040) of the US Environmental Protection Agency UNAMAP model series.

The meteorological frequency program used to identify the frequency of occurrence of atmospheric stability classes by season and by wind speed and direction is the GRP 115 STAR program developed by the Waste Management Branch Meteorological Unit in Victoria. It, too, has its limitations. The atmospheric stability classes generated by this program are derived from surface based observations and theoretical calculations.

Results and Discussion

Total Suspended Particulate

The annual geometric means of the total suspended particulate data for Castlegar, plus representative stations in Trail and Vancouver are presented in Table 8.

The levels of total suspended particulate in Castlegar are lower than at the Trail stations and at Coquitlam Municipal Hall and somewhat higher than at English Bluff. The former stations are influenced by industrial emissions while the latter is well removed from any industrial influence.

There were no annual geometric means in excess of the provincial environmental objective levels at Castlegar. As well, there are no strong, consistent, long term trends in this

analysis (Figure 9). During 1981 - 1985 the geometric means are more consistent than during the previous 6 years with a slight increase in 1986. This pattern is quite possibly within the limits of natural variation expected in such a diverse and complex system (R. Davis, Ministry of Environment and Parks, Pers. Comm., 1987).

Table 8: Annual geometric means of suspended particulate levels for stations in Castlegar, Trail and Vancouver.

Year	Castlegar Centennial Library	Trail Butler Park	Oasis	Vancouver English Bluff	Coquitlam Mun. Hall
1975	41.03	68.14			
1976	45.07	63.08			
1977	41.89	64.96	38.89		
1978	37.55	60.84	45.22		
1979	45.22	66.92	47.92		
1980	45.43	58.67	53.20		
1981	39.41	67.31	43.34	31	68
1982	38.21	50.67	56.77	29	61
1983	38.40	50.65	46.43	23	45
1984	38.39	41.95	51.03	19	50
1985	39.07	43.41	43.88	29	64
1986	41.61			24	54

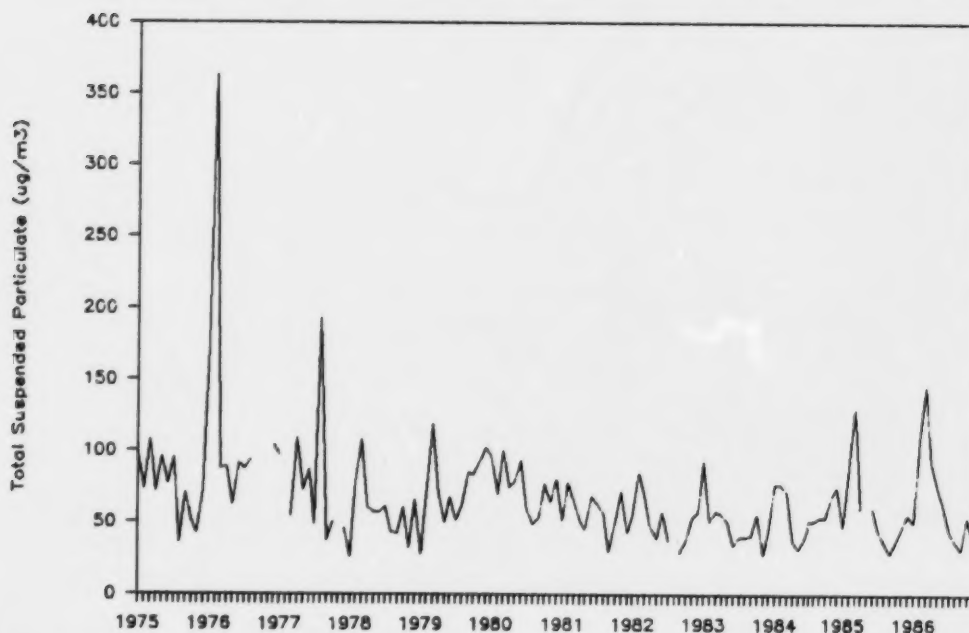


Figure 9: Annual geometric means of total suspended particulate observed at Castlegar.

The MODO total reduced sulphur gas scrubber at the Celgar Pulp Company mill became operational in early 1980. This unit should have contributed to a decrease in suspended particulate emissions from the recovery boiler. While it may have contributed to the 1981 - 1985 consistency discussed above, the lack of an obvious decrease in the measured total suspended particulate indicates that the recovery boiler is not the sole or, perhaps, even a major contributor of this contaminant. Other possible seasonal sources would be gravel pit operations and the small asphalt plants in the area.

The high values of early 1976 and mid-1977 (Appendix I), resulting in the peaks visible in Figure 10, are considered anomalous in this data set. The readings in 1976 are a series of high values (in excess of 300 ug/m^3) and the peak in August 1977 results from a single reading of 715 ug/m^3 . The peak in 1976 likely results from a real event - a local construction project perhaps - but it has never recurred, nor has any individual reading similar to the 1977 maximum. Therefore the 1978 - 1985 data are considered to be representative of the current situation for the purposes of seasonal analysis.

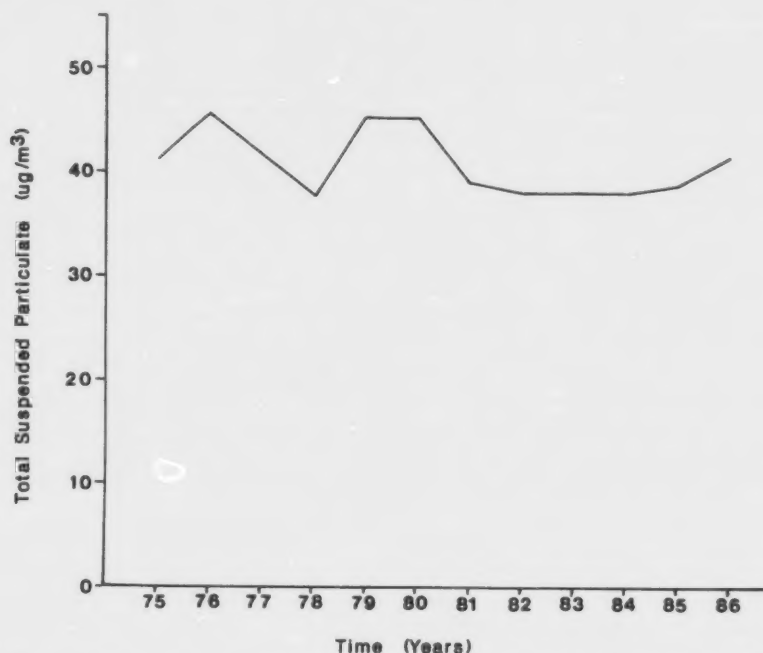


Figure 10: Graph of monthly average total suspended particulate levels observed at the Centennial Library for 1978 - 1986.

The arithmetic monthly averages of the total suspended particulate data (1978 - 1986) are presented in Figure 11. This shows an apparent maximum in early spring and a minimum in late summer. A possible explanation is the re-entrainment of particles from road dust. The late winter/early spring is the time of year

when the residue of an entire winter's sanding operations is lying on the streets in relatively dry conditions, available for such re-entrainment. This would result in concurrent maxima in total suspended particulate and dustfall. This explanation is not the whole story of the total suspended particulate levels as the seasonal trend is not initially obvious.

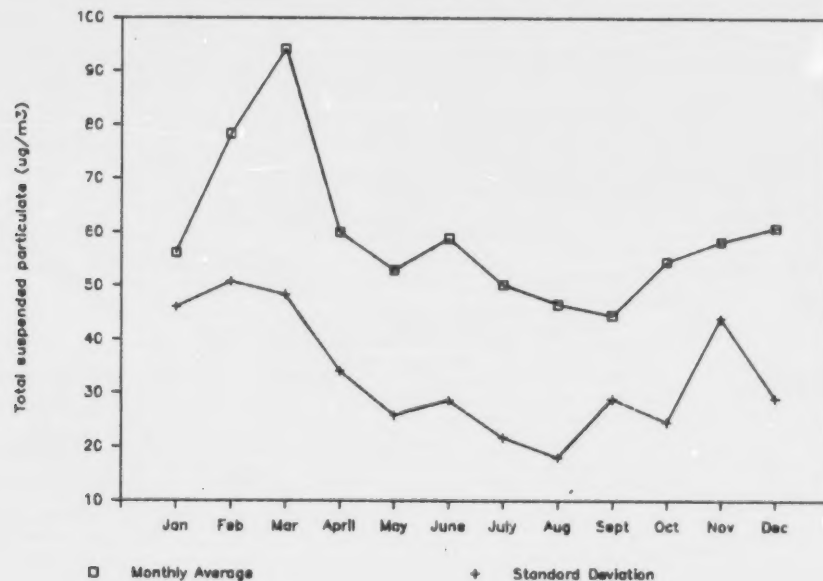


Figure 11: Graph showing annual monthly averages of total suspended particulate data gathered at the Centennial Library (1976 - 1986).

The variation in standard deviation associated with these averages is as would be expected considering the changes in dispersive capacity of the atmosphere with the seasons. There is an inconsistently high standard deviation associated with the monthly averages of November through March and consistently low standard deviations associated with the May to October averages.

The winter atmosphere is generally more stable than the summer atmosphere due to the decreased ground temperatures, resulting in the occurrence of more meso-scale inversions (relatively long term, regional events). During such inversions all atmospheric contaminants would be contained in the valley and the levels of any contaminants which continued to be emitted would increase for the duration of the event. The weather between such events is likely to be quite capable of clearing contaminants via winter storms through the mechanisms of dispersion in the wind or wet deposition with precipitation. Thus the potential exists for the occurrence of both extreme high and extreme low levels of atmospheric contaminants such as total suspended particulate, sulphur dioxide and total reduced sulphur gases.

The number of individual samples that were above the provincial environmental objective levels for Castlegar and two stations in Trail are given in Table 9.

Table 9: Number of excursions above provincial environmental objectives levels of total suspended particulate samples for stations in Castlegar and Trail.

Year	Castlegar Centennial Library	Trail Butler Park	Oasis
1975	3/1	7/3	
1976	9/8	5/1	
1977	3/2	2/-	4/2
1978	2/-	1/-	4/2
1979	2/-	1/-	7/3
1980	3/1	2/1	6/3
1981	1/-	3/-	-/-
1982	-/-	2/1	4/1
1983	1/1	2/-	2/1
1984	1/-	2/-	2/1
1985	2/-	-/-	2/-
1986	6/2		
Percent occurring Sept/Mar	85/87	56/50	94/100

Note : Figures are Level A exceedances / Level B exceedances as shown in Table 3.

Previous work (White et al., 1986) concluded that the total suspended particulate levels recorded at Butler Park were a result of the relatively direct influence of the smelter emission plume in that area, whereas the levels observed at Oasis were weather controlled. The Castlegar situation appears to be more similar to Oasis as most of the samples that exceed provincial environmental objective levels occur during the fall and winter months.

Dustfall

The annual average values of total particulate dustfall for stations in Castlegar, Trail and Vancouver are presented in Table 10. There are no obvious long term trends in the Castlegar data. The values recorded at Castlegar are comparable to those found in Vancouver and Oasis (near Trail) and lower than those found in central Trail (Butler Park).

The average monthly values of total particulate dustfall for the Centennial Library station are graphed in Figure 12. These show a peak during February - March and a minimum in late fall. The form and shape of this curve is similar to that found in the analysis of suspended particulate data. This may indicate a common source and/or a common controlling (i.e. meteorological)

Table 10: Annual average dustfall levels for stations in Castlegar, Trail and Vancouver.

Year	Castlegar Centennial Library	Airport (MoEP)	Airport (Cominco)	Trail Butler Park	Oasis	Vancouver Coquitlam Mun. Hall	English Bluff
1975	0.97	0.93	0.331	1.75			
1976	0.75	0.41	0.332	0.86			
1977	0.79	0.67	0.454	0.91	1.34		
1978	0.72	0.99	0.386	0.84	1.06		
1979	0.72	0.91	0.53	1.46	0.83		
1980	0.77	0.98	0.68	1.22	0.96		
1981	0.79		0.93	1.13	0.68	1.2	0.5
1982	0.81		0.58	1.38	0.83	1.1	0.7
1983	0.71		0.70	1.48	0.70	0.9	0.7
1984	0.79		0.45	1.42	1.00	0.7	0.6
1985	0.91		0.51	1.33	0.54	0.8	
1986	0.83					1.0	0.4

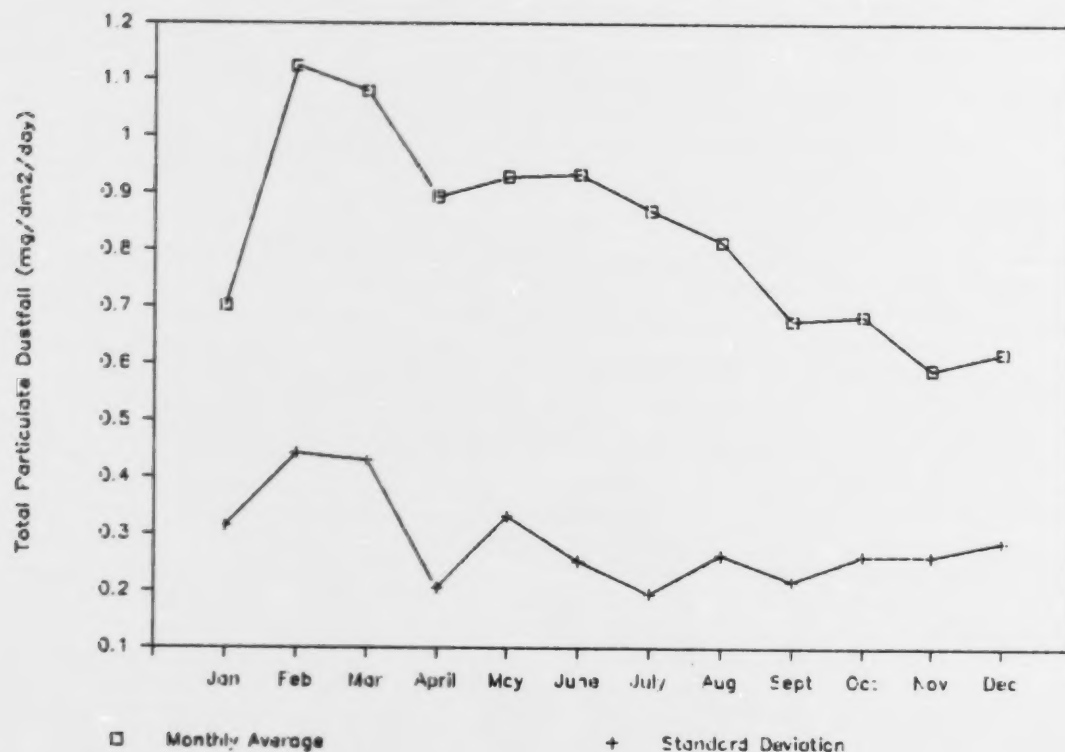


Figure 12: Graph of average dustfall levels observed at the Centennial Library.

mechanism. For example, the accumulation of fine sand in the snow banks on road sides during the winter is a potential source of dustfall and total suspended particulate material (through re-entrainment of such material by the wind) when the snow melts in the spring could be such a source.

Other possible sources of dustfall are gravel pits, asphalt plants, flyash from waste burning, etc. However given the amount and quality of the data available for this report, it would be highly speculative to discuss the relative effects of their contributions.

The lead and zinc content of the dustfall samples collected at the Castlegar Airport and Centennial Library stations is consistently lower than those observed in Trail (Table 11, White et al., 1986). The probable explanation for this difference is the emission of metals into the atmosphere by the Cominco Ltd. smelter in Trail. As indicated earlier dustfall particles, because of their relatively large size, would have the greatest impact within 2 km of their source.

Table 11: Average lead and zinc content (in mg/dm²/day) of dustfall collected at Castlegar Airport and Centennial Library for 1975 -1986.

	Lead	Zinc
Castlegar Airport		
Average	0.00206	0.00339
Maximum	0.00701	0.00876
Minimum	0.001	0.00117
Centennial Library		
Average	0.00171	0.00242
Maximum	0.00467	0.00584
Minimum	0.001	0.00082

Sulphation Rate

There are no environmental objectives pertaining to sulphation rate. These data are gathered as indicators of long term trends in ambient atmospheric sulphur. The environmental objectives for atmospheric sulphur are different for sulphur dioxide (as emitted by the Cominco Ltd. smelter) and total reduced sulphur compounds (as emitted by the Celgar Pulp Company mill). Research (Lynch et al., 1978) conducted in Trail has produced a conversion factor to convert sulphation rate to ambient atmospheric sulphur of 13.9 (ug/m³)/(ug/cm²/day) with an uncertainty of 1.3 units in an average wind of 7.5 kmh. The annual average sulphation rate and the results of this calculation for the Centennial Library station are given in Table 12.

The calculated levels are in all cases well below the provincial ambient air quality objective of 25 ug/m³ for sulphur

Table 12: Annual average sulphation rate and approximate annual average concentration of atmospheric sulphur at the Castlegar library

Year	Sulphation Rate (mg/dm ² /day)	Concentration of Atmospheric Sulphur (ug/m ³)
1975	0.47	0.66
1976	0.41	0.57
1977	0.32	0.45
1978	0.40	0.56
1979	0.39	0.55
1980	0.32	0.45
1981	0.22	0.31
1982	0.38	0.53
1983	0.39	0.54
1984	0.35	0.48
1985	0.36	0.50
1986	0.24	0.33

Note: the conversion factor used was 1.39 to compensate for the change in units: (ug/m³)/(ug/cm²/day) to (ug/m³)/(mg/dm²/day).

dioxide. There is no published annual environmental objective for total reduced sulphur gases. Given the indeterminant nature of sulphation rate data it is assumed that these results are a general indication of atmospheric sulphur levels, however this is probably not a valid comparison, in a rigorous scientific sense.

All of the sulphation rate data collected north of Oasis show a strong seasonal trend (Figure 13) with a distinct peak in the winter months. The valley is affected as a unit, in that there is no lineal relationship between the magnitude of the peaks and the distance from the smelter - the peaks at Castlegar airport are similar in size to the peaks at Rivervale.

This phenomenon is assumed to be due to the confinement and resulting concentration of sulphur emissions during the winter. The valley appears to be confining and, as a result, concentrating the ambient sulphur gas during the poor dispersion conditions which prevail during the winter months. However, given the indiscriminant nature of sulphation rate data, we cannot identify which source of atmospheric sulphur is responsible - Cominco Ltd. operations at Trail or the Celgar Pulp Company mill operations at Castlegar.

However, there are a number of factors which indicate that the Cominco Ltd. emissions may play a role in this increase in atmospheric sulphur:

i) it is likely that there is a significant difference in the volume of sulphur gases emitted from the two operations - environmental objective level B for sulphur dioxide, the principle emission from a lead/zinc smelter is 900 ug/m³ versus

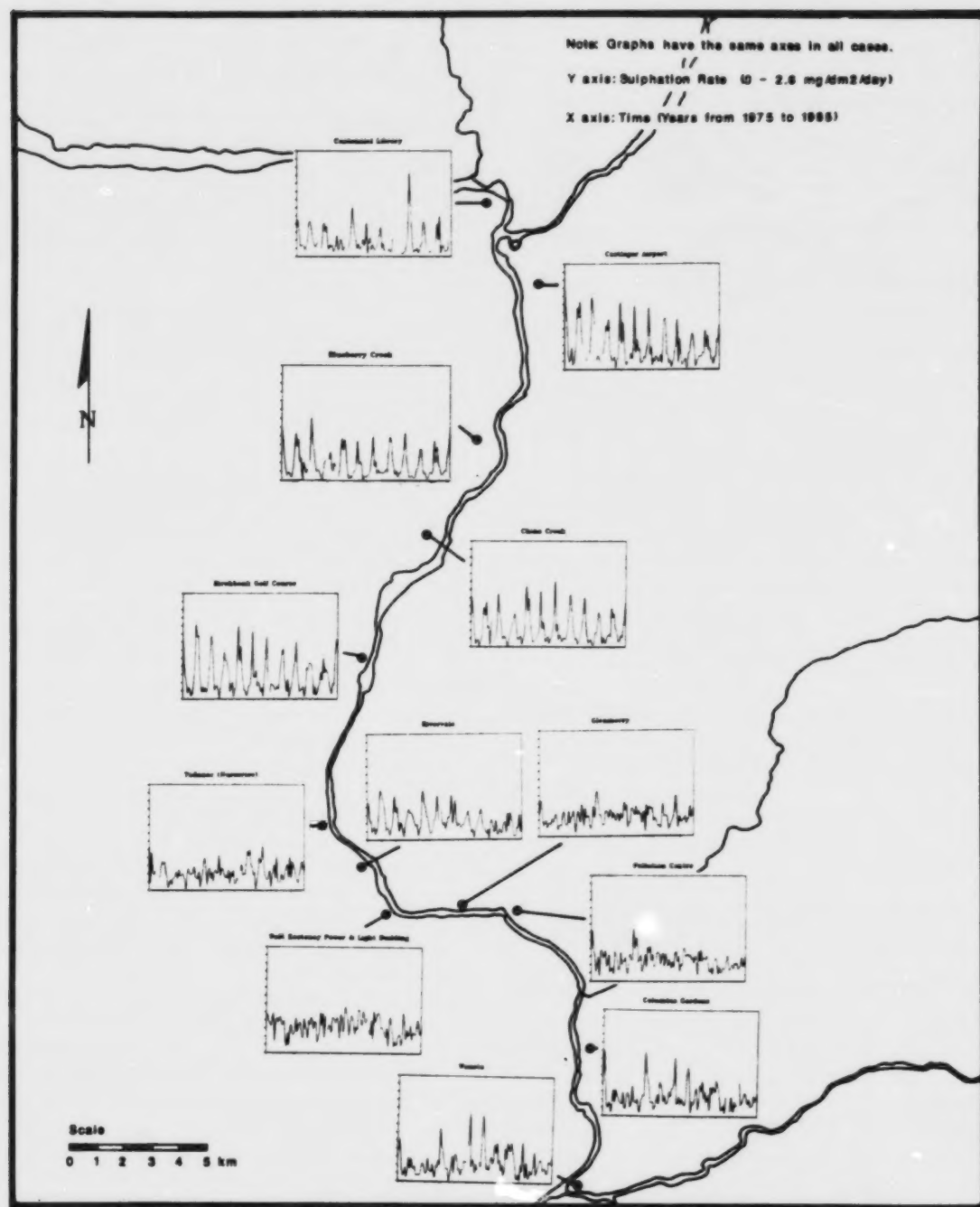


Figure 13: Diagram showing variation in sulphation rate with location in the Columbia River valley.

28 ug/m³ for total reduced sulphur gas, the principle emission from pulp mills. The sulphation plates are thought to be equally efficient in the collection of SO₂ and H₂S, and therefore, if the relative contribution of the two sources is reflected by the air quality objectives the potential contribution of the smelter is 30 times that of the pulp mill.

ii) the results of a computer modelling of the Cominco Ltd. plume indicate that significant ambient concentrations of sulphur dioxide may result from the smelter plume over 20 km from the smelter (Table 13), especially under conditions of low wind with a stable or neutral atmosphere.

Table 13: The distance to and magnitude of predicted concentrations of SO₂ resulting from Cominco Ltd. emissions under various atmospheric and wind conditions.

	Unstable	Neutral	Stable
Low wind			
Distance to maximum concentration (km)	2	22	21
Maximum concentration (ug/m ³)	739.5	167.6	450.5
Concentration at 30 km (ug/m ³)	75.5	159.2	440.4
Moderate wind			
Distance to maximum concentration (km)	1	4	9
Maximum concentration (ug/m ³)	918.5	412.6	276.5
Concentration at 30 km (ug/m ³)	15.1	84.7	18.3
High wind			
Distance to maximum concentration (km)	1	2	7
Maximum concentration (ug/m ³)	626.6	457.2	208.8
Concentration at 30 km (ug/m ³)	7.6	45.1	109.2

Notes:

- i) Emission levels representative of the annual average emissions were used in this model.
- ii) The unstable, neutral and stable categories used here (and in Tables 12 & 13) refer to the vertical stability of the atmosphere. This is a measure of resistance, or lack thereof, of the atmosphere to the vertical diffusion of a plume. These are not a measure of calmness or wind. It is possible to have a stable atmosphere (an inversion) and have air movement (wind) underneath the stable layer.

Frequency analysis of the available weather data indicate that there is an increase in the frequency of neutral and stable atmospheric conditions in the fall and winter. This fact alone will explain the increase in sulphation rate. However the frequency of southerly (from the direction of Cominco Ltd. operations) and northwesterly (from the direction of Celgar Pulp Company operations) winds occurring concurrently with such conditions is similar (Table 14).

Table 14: Frequency of occurrence of neutral and stable atmospheric conditions with low winds (<1.5 m/s) by season at Castlegar airport.

Seasons (months)	Atmospheric conditions		summation
	neutral	stable	
Winter (DJF)	66.9	24.0	90.9
Spring (MAM)	40.2	31.3	71.5
Summer (JJA)	24.6	31.4	56.0
Fall (SON)	43.2	35.6	78.8

with southerly winds (up river)

Winter (DJF)	11.4	6.4	17.8
Spring (MAM)	4.7	7.0	11.7
Summer (JJA)	1.6	6.6	8.2
Fall (SON)	8.2	9.8	18.0

with northwesterly winds (down river)

Winter (DJF)	6.5	3.9	10.4
Spring (MAM)	3.5	2.3	5.8
Summer (JJA)	1.2	8.3	9.5
Fall (SON)	3.6	7.5	11.1

Notes:

The figures are percentages. For example, in the winter unstable atmospheric conditions occur $100 - 90.9 = 9.1\%$ of the time. And 11.4% of the time (17% of the time of neutral conditions) there were both neutral atmospheric conditions and winds from the south quadrant.

Previous work (Kotturi, 1980) found a difference in metal corrosion rates between sites near Castlegar, Trail and Nelson. This difference was attributed to the different pollutants which were likely to be present in each area. It is reasonable that the pulp mill emissions are having an effect at the Castlegar airport, however it is not obvious nor likely that this seasonal increase throughout this area of the valley is solely due to these emissions.

Therefore the increase in sulphation rate cannot, with the data currently available, be attributed to one or the other of the major industrial operations in the area, nor can the relative contribution of either be quantified.

An attempt was made to assess the affect of elevation on sulphation rate using some of the Cominco Ltd. data. This investigation proved to be inconclusive, raising more questions regarding the reliability and applicability of the data than insight into elevation and plume interaction. The results are presented in Appendix III.

Total Reduced Sulphur

The Ministry of Environment and Parks uses a single instrument, located on the roof of the Castlegar Regional Hospital, to monitor the ambient levels of total reduced sulphur gas in the Castlegar area. Given the potential for localized plume impacts resulting from various weather and wind conditions, and the geographic complexity of the area, it is possible that another location would result in very different data. A change in location may produce data indicating higher average ambient levels of total reduced sulphur gas or a greater number of exceedance events, times when the ambient levels of total reduced sulphur gas exceed the air quality objectives. This could easily be the case if the monitor were located in Robson, for example. Indeed, it has been observed that under certain atmospheric conditions the plume flows down gullies as it moves over the shoulder behind Castlegar and is channeled away from the hospital (R. Crozier, C. Johnson, direct observation, April 30, 1987). This should be kept in mind when considering the results presented below.

The number of times that the ambient levels of total reduced sulphur gases exceed the provincial air quality "B" level objective in Castlegar is comparable with those in Prince George (Figure 14). The situation in Prince George has been identified as an air quality problem and a major effort is underway to quantify all emission sources in the area and study their relative contribution to the air quality in the vicinity.

The situation in Castlegar is that of an old mill operating near or above its design capacity and consequently overloading its emission control equipment resulting in the emission of high levels of total reduced sulphur gases. There are many days when the maximum concentration of total reduced sulphur gas in the recovery boiler stack is greater than 150 PPM and some days when the minimum concentration is also greater than 150 PPM (Appendix II).

There is no strong correlation between days of high emission levels and increased ambient levels of total reduced sulphur gas at the hospital (Figure 15). The relationship between total reduced sulphur emissions and ambient levels (and exceedance events) in a specific area removed from the source is a result of the interaction of atmospheric conditions into which the gas is emitted and the volume and quality of those emissions.

Work in Prince George (Bennett, et al., 1986) exploring the interaction of atmospheric conditions and emissions, as pollutants impact the environment identified the low level sources from the various pulp mills in the area as being responsible for creating high ambient levels in the town. Hence, controlling the emissions which impact people requires cleaning up the many minor sources rather than the main stacks. There are differences between the Castlegar situation and that of Prince George, in terms of both geography and mill design, however these

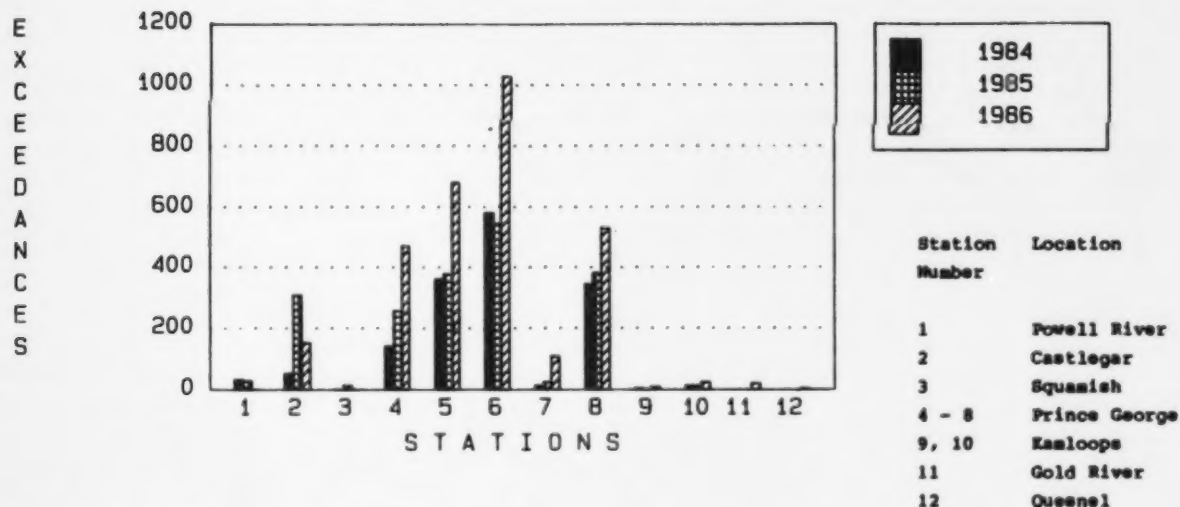


Figure 14: Graph showing relative number of exceedance events above environmental objective level B of stations in B.C.

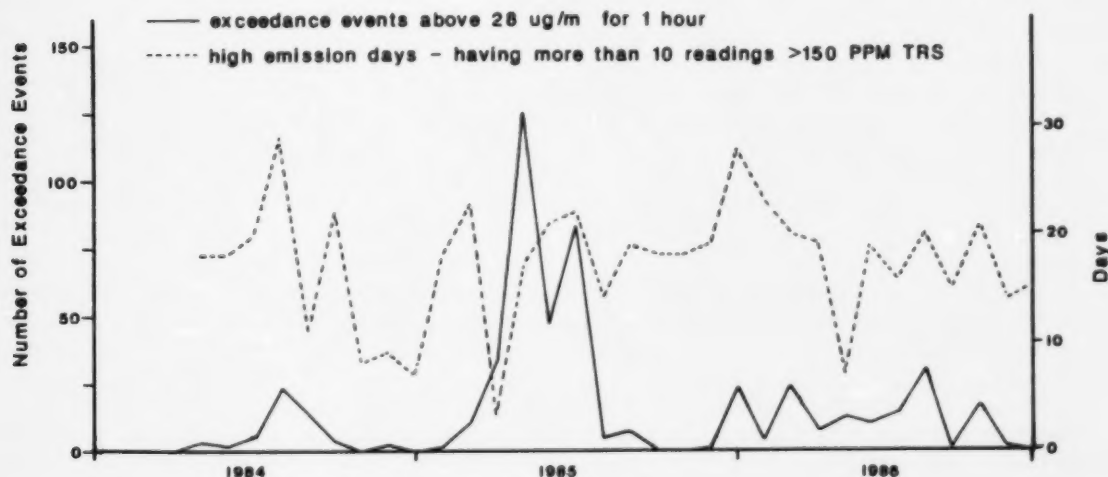


Figure 15: Graph showing number of exceedance events above the air quality objective level B for TRS and number of days of poor quality emissions from the Celgar Pulp Company's recovery boiler, during 1984 - 1986.

differences do not preclude the possibly significant contribution of the low levels sources to the air quality of Castlegar. A complete inventory of emission sources at the Celgar Pulp Co. mill, coupled with further modelling and analysis, is required

before we can delineate the relative contributions of the recovery boiler plume and the minor sources plume(s) to the exceedance events observed.

The plume of the Celgar Pulp Company mill recovery boiler was modelled in a preliminary fashion in an attempt to determine if a similar situation was occurring in Castlegar. The results are presented in Table 15.

Table 15: Range of potential ambient total reduced sulphur gas levels above 28 ug/m³ (in km from the pulp mill) under various wind and atmospheric conditions.

Wind Strength	Mixing Height (m)	Unstable Air	Neutral Air	Stable Air
Low	100	*	*	-
	200	*	*	-
	500	1.2 - 7.0	-	-
Moderate	100	*	*	-
	200	0.6 - 3.0	2.4 - 6.4	-
	500	0.4 - 1.8	2.6 - 6.0	-
High	100	0.4 - 3.0	1.6 - 7.6	-
	200	0.6 - 1.4	-	-
	500	0.6 - 1.2	-	-

Notes:

- i) * indicates that the modelled plume rise is higher than the mixing height and is isolated from the ground.
- ii) under stable atmospheric conditions the mixing height becomes irrelevant as there is no limited vertical mixing of the atmosphere.

These results indicate that under unstable atmospheric conditions with low winds and under neutral atmospheric conditions with moderate winds the plume of the recovery boiler could indeed impact Castlegar, resulting in ambient levels of total reduced sulphur gas above the provincial environmental objective level of 28 ug/m³.

A frequency analysis of the available weather data (wind data from the BCHPA Dam supplemented with data from Castlegar Airport) was conducted to ascertain the likelihood of these theoretical impacts. The results of this analysis (Table 16) indicate that there is a slight increase in the conditions conducive to the plume impacting Castlegar in the spring and summer. The small magnitude of this difference may be reflected in the lack of an obvious seasonal trend in exceedance events.

The model predicts no impact on the town under stable atmospheric conditions. Under these conditions the model

Table 16: Percent frequency of occurrence of conditions at the BCHPA Dam which could lead to plume impact on Castlegar.

Atmospheric conditions	unstable	neutral	summation
Wind	0 - 1.5 m/s	3.6 - 5.1 m/s	
Winter (DJF)	1.23	6.36	7.59
Spring (MAM)	4.83	5.31	10.14
Summer (JJA)	6.9	3.68	10.58
Fall (SON)	3.56	5.05	8.61

indicates that the plume rises to a height of 272 m and does not disperse back down to ground level in the distance between the mill and the town. Under stable atmospheric conditions events of high ambient levels of total reduced sulphur gases in Castlegar must result from sources other than the plume from the main stack if the model is correct.

This analysis is not be presumed to be the final word on the air quality in Castlegar, but is presented as what can be done with the available data. To draw conclusions with confidence would require more in-depth analysis of the existing data and higher quality emission data.

Other Emissions

Total particulate and bivalent sulphur emissions data supplied to the Ministry of Environment and Parks (Appendix II: Other Emission Data) indicate that these emissions are within the permit levels in all cases.

Summary

1. There are no obvious long term trends in total suspended particulate levels. The observed levels are generally within the air quality objectives defined by the provincial government.
2. The occurrence of high ambient levels of total suspended particulate appears to be determined by the dispersive capability of the atmosphere, and are most likely to occur in late winter and early spring.
3. Total suspended particulate and dustfall levels show a similar seasonal pattern.
4. There are no obvious long term trends in dustfall levels, and these levels are generally below the air quality objectives defined by the provincial government.
5. The lead and zinc content of dustfall samples collected in Castlegar is substantially lower than that found in Trail.
6. The sulphation rate data show consistent marked winter maxima for stations between Trail and Castlegar. The cause of this is thought to be the reduced dispersive capability of the winter atmosphere.
7. The analysis presented here indicates that emissions from Cominco Ltd. operations at Trail and those of the Celgar Pulp Company mill at Castlegar contribute to the above phenomena, however it is not possible to quantify their relative contributions.
8. The number of times when the ambient total reduced sulphur levels exceed the provincial air quality objectives at Castlegar was 142, these events occurred on 49 non-consecutive days.
9. The occurrences of high ambient levels of total reduced sulphur gases are more likely in the late spring and summer months, and appear to be weather controlled.
10. Preliminary computer modelling of the main stack emission plume from the Celgar Pulp Company mill indicates that this stack may be a contributing source of these high ambient levels of total reduced sulphur gases.
11. Particulate and bivalent sulphur emissions data from the Celgar Pulp Company mill indicate that these emissions are within permit levels.

Recommendations

1. The value of the long term data base and its possible future applications, such as quantifying subsequent emission improvements and correlating these to environmental or health affects, should be considered carefully before any ambient air monitoring is dropped in this area of the Columbia River valley.
2. The air quality of the Columbia River valley in the vicinity of Castlegar and Trail appears to be affected by the emissions from all sources in the area. A meaningful emission/air quality relationship can be determined only if the quality of the emission, ambient air quality and weather data are upgraded.
3. Cominco Ltd. operated 30 air monitoring stations between Castlegar and Waneta until 1985. Some of the data from these stations has proved extremely valuable to this report, and it is recommended that this value be assessed, with the potential of re-commissioning of some of these stations. (see Appendix III)
4. There are major improvements being planned at both the Cominco Ltd. operations and the Celgar Pulp Company mill which should significantly decrease emissions from both sources. These improvements, which are anticipated to take place within 3 - 5 years, will in effect provide a major environmental/industrial experiment. It is recommended that the monitoring requirements necessary to derive maximum value from this be explored fully. The results of such monitoring and its contribution to our understanding the dynamics of emission - environment interaction could be applicable in other areas of British Columbia.
5. A continuous ambient total reduced sulphur gas analyzer should be installed in the Robson area, across the river from the Celgar Pulp Company mill. The existing analyzer, located at the Castlegar Regional Hospital may register low ambient concentrations of total reduced sulphur gases when unacceptable high ambient concentrations exist in the Robson area. Any ambient limits specified in the Variance order or Waste Management Permit should also apply to the Robson monitoring site.
6. A complete inventory of all emission sources should be undertaken for the Celgar Pulp Co. mill. This inventory should include both quantity and quality data. It could be used to determine the relative contribution of the various sources to the exceedance events observed. Such analysis would identify the most significant impacting sources and allow cost effective improvements (with respect to air quality) to be planned.
7. A high volume air sampling station should be established at Castlegar Airport. Analysis of sodium, lead and zinc levels of the samples from this station and the existing downtown Castlegar

station should be undertaken. The purpose of this analysis is to identify the source of the airborne material. High sodium levels would indicate pulp mill emissions while high lead and zinc levels would indicate smelter emissions.

8. Further research into the correlation of sulphation rate with all ambient sulphur gases must be undertaken to assess the value of the existing sulphation rate data. This should include an assessment of the relative rates of collection of the various sulphur gases, the effect of changing atmospheric conditions on these rates and a thorough literature search of all existing work. This work could include setting up parallel sulphation stations with all existing continuous sulphur dioxide and total reduced sulphur gas monitors and comparing the results through time. (see Appendix III)

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Appendix I

Air Quality Data



Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
3/01/75	48.1
9/01/75	45.4
15/01/75	12.1
21/01/75	146.0
27/01/75	240.0
2/02/75	13.2
8/02/75	59.8
14/02/75	73.0
23/02/75	148.0
1/03/75	59.6
7/03/75	138.5
13/03/75	149.3
19/03/75	134.2
25/03/75	118.1
31/03/75	46.6
6/04/75	44.0
12/04/75	121.0
18/04/75	80.1
24/04/75	23.6
30/04/75	88.5
6/05/75	79.0
12/05/75	106.0
18/05/75	61.0
24/05/75	72.0
30/05/75	161.0
5/06/75	72.0
11/06/75	125.0
17/06/75	73.0
23/06/75	63.0
29/06/75	51.0
5/07/75	154.3
11/07/75	146.3
17/07/75	39.6
29/07/75	39.5
4/08/75	33.0
10/08/75	36.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
16/08/75	56.0
22/08/75	37.0
28/08/75	20.0
3/09/75	36.0
9/09/75	65.0
15/09/75	117.0
21/09/75	46.0
27/09/75	90.0
3/10/75	64.0
9/10/75	54.0
15/10/75	67.0
21/10/75	26.0
27/10/75	43.0
2/11/75	55.0
8/11/75	38.0
14/11/75	34.0
14/12/75	109.0
20/12/75	60.0
26/12/75	46.0
1/01/76	316.0
7/01/76	95.0
13/01/76	268.0
19/01/76	278.0
25/01/76	280.0
31/01/76	460.0
6/02/76	666.0
12/02/76	259.0
18/02/76	151.0
24/02/76	377.0
1/03/76	81.0
7/03/76	52.0
13/03/76	103.0
19/03/76	155.0
25/03/76	93.0
31/03/76	42.0
6/04/76	129.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
12/04/76	73.0
18/04/76	40.0
24/04/76	63.0
30/04/76	139.0
6/05/76	78.0
18/05/76	95.0
24/05/76	55.0
30/05/76	20.0
5/06/76	92.0
11/06/76	94.0
17/06/76	84.0
23/06/76	93.0
5/07/76	107.0
11/07/76	67.0
4/08/76	75.0
10/08/76	108.0
22/08/76	127.0
28/08/76	62.0
20/12/76	104.0
1/01/77	94.2
13/01/77	99.5
19/01/77	23.2
25/01/77	115.0
31/01/77	155.0
2/03/77	36.9
8/03/77	21.6
14/03/77	85.1
20/03/77	75.7
1/04/77	95.0
7/04/77	234.0
13/04/77	37.0
19/04/77	38.0
25/04/77	140.0
1/05/77	110.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
7/05/77	65.0
13/05/77	66.0
19/05/77	64.0
25/05/77	84.0
31/05/77	48.0
6/06/77	115.0
12/06/77	65.0
18/06/77	127.0
24/06/77	97.0
30/06/77	83.0
6/07/77	44.0
12/07/77	28.0
18/07/77	46.0
24/07/77	77.0
5/08/77	47.0
11/08/77	140.0
17/08/77	715.0
23/08/77	43.0
29/08/77	18.0
4/09/77	32.0
10/09/77	42.0
16/09/77	25.0
22/09/77	69.0
28/09/77	20.0
4/10/77	58.0
10/10/77	26.0
16/10/77	58.0
22/10/77	78.0
28/10/77	30.0
3/12/77	59.0
9/12/77	15.0
15/12/77	35.0
21/12/77	87.0
27/12/77	32.0
2/01/78	6.0
8/01/78	7.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
14/01/78	12.0
20/01/78	27.0
26/01/78	77.0
1/02/78	12.0
7/02/78	29.0
13/02/78	114.0
19/02/78	159.0
25/02/78	77.0
3/03/78	128.0
9/03/78	157.0
15/03/78	112.0
21/03/78	108.0
27/03/78	32.0
2/04/78	27.0
8/04/78	98.0
14/04/78	66.0
20/04/78	38.0
26/04/78	73.0
2/05/78	57.0
8/05/78	83.0
14/05/78	21.0
20/05/78	75.0
26/05/78	51.0
1/06/78	96.0
7/06/78	113.0
13/06/78	16.0
19/06/78	34.0
25/06/78	28.0
1/07/78	29.0
7/07/78	71.0
13/07/78	62.0
19/07/78	58.0
25/07/78	84.0
31/07/78	64.0
6/08/78	49.0
12/08/78	69.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
18/08/78	29.0
24/08/78	25.0
30/08/78	43.0
5/09/78	24.0
17/09/78	28.0
23/09/78	38.0
29/09/78	79.0
5/10/78	66.0
11/10/78	39.0
17/10/78	59.0
23/10/78	77.0
10/11/78	32.0
28/11/78	33.0
4/12/78	67.0
10/12/78	48.0
16/12/78	81.0
3/01/79	15.0
21/01/79	39.0
27/01/79	29.0
2/02/79	81.0
8/02/79	46.0
14/02/79	71.0
20/02/79	75.0
26/02/79	56.0
4/03/79	101.0
10/03/79	193.0
16/03/79	113.0
28/03/79	65.0
3/04/79	75.0
9/04/79	54.0
15/04/79	42.0
21/04/79	35.0
27/04/79	143.0
3/05/79	61.0
9/05/79	41.0
27/05/79	48.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
2/06/79	95.0
8/06/79	55.0
14/06/79	52.0
20/06/79	35.0
26/06/79	99.0
2/07/79	26.0
8/07/79	33.0
14/07/79	46.0
20/07/79	98.0
26/07/79	54.0
1/08/79	70.0
7/08/79	74.0
13/08/79	66.0
25/08/79	50.0
31/08/79	48.0
6/09/79	68.0
12/09/79	74.0
18/09/79	95.0
24/09/79	128.0
30/09/79	60.0
12/10/79	154.0
18/10/79	64.0
24/10/79	23.0
30/10/79	93.0
5/11/79	32.0
11/11/79	141.0
17/11/79	111.0
23/11/79	119.0
29/11/79	60.0
5/12/79	94.0
17/12/79	94.0
23/12/79	119.0
4/01/80	200.0
10/01/80	44.0
16/01/80	46.0
3/02/80	113.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
9/02/80	27.0
15/02/80	31.0
21/02/80	116.0
27/02/80	62.0
4/03/80	80.0
10/03/80	79.0
16/03/80	82.0
22/03/80	155.0
28/03/80	103.0
9/04/80	68.0
15/04/80	67.0
21/04/80	66.0
27/04/80	97.0
3/05/80	66.0
9/05/80	23.0
15/05/80	131.0
21/05/80	93.0
2/06/80	69.0
8/06/80	88.0
14/06/80	75.0
20/06/80	141.0
8/07/80	97.0
14/07/80	30.0
20/07/80	27.0
26/07/80	81.0
7/08/80	49.0
13/08/80	71.0
19/08/80	44.0
25/08/80	47.0
31/08/80	34.0
12/09/80	33.0
18/09/80	56.0
24/09/80	84.0
30/09/80	42.0
6/10/80	78.0
12/10/80	80.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
18/10/80	74.0
5/11/80	56.0
11/11/80	21.0
17/11/80	183.0
23/11/80	13.0
29/11/80	47.0
5/12/80	31.0
11/12/80	78.0
17/12/80	135.0
23/12/80	39.0
29/12/80	118.0
4/01/81	57.0
10/01/81	83.0
16/01/81	55.0
22/01/81	40.0
28/01/81	21.0
3/02/81	63.0
21/02/81	103.0
27/02/81	67.0
5/03/81	84.0
11/03/81	109.0
17/03/81	61.0
23/03/81	26.0
29/03/81	48.0
4/04/81	40.0
10/04/81	56.0
16/04/81	85.0
22/04/81	24.0
4/05/81	58.0
10/05/81	46.0
16/05/81	31.0
22/05/81	46.0
3/06/81	67.0
9/06/81	46.0
15/06/81	68.0
21/06/81	39.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
27/06/81	122.0
3/07/81	106.0
9/07/81	85.0
15/07/81	52.0
21/07/81	25.0
27/07/81	45.0
2/08/81	36.0
8/08/81	46.0
14/08/81	78.0
20/08/81	24.0
26/08/81	96.0
1/09/81	24.0
7/09/81	17.0
13/09/81	31.0
19/09/81	42.0
25/09/81	34.0
1/10/81	33.0
7/10/81	43.0
13/10/81	22.0
19/10/81	90.0
25/10/81	61.0
31/10/81	47.0
6/11/81	31.0
12/11/81	27.0
18/11/81	184.0
24/11/81	44.0
6/12/81	33.0
12/12/81	49.0
18/12/81	29.0
24/12/81	72.0
30/12/81	34.0
5/01/82	83.0
11/01/82	75.0
17/01/82	14.0
23/01/82	69.0
29/01/82	32.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
4/02/82	81.0
10/02/82	45.0
16/02/82	48.0
22/02/82	135.0
28/02/82	115.0
6/03/82	96.0
12/03/82	79.0
18/03/82	85.0
24/03/82	56.0
30/03/82	29.0
5/04/82	33.0
11/04/82	35.0
17/04/82	42.0
23/04/82	91.0
29/04/82	34.0
17/05/82	32.0
23/05/82	32.0
29/05/82	54.0
4/06/82	54.0
10/06/82	69.0
16/06/82	86.0
22/06/82	49.0
28/06/82	28.0
4/07/82	18.0
10/07/82	36.0
16/07/82	21.0
22/07/82	41.0
28/07/82	72.0
8/09/82	33.0
14/09/82	20.0
20/09/82	37.0
26/09/82	26.0
2/10/82	35.0
8/10/82	36.0
14/10/82	51.0
20/10/82	47.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
26/10/82	19.0
1/11/82	17.0
7/11/82	33.0
13/11/82	84.0
19/11/82	17.0
25/11/82	113.0
1/12/82	34.0
7/12/82	26.0
13/12/82	62.0
19/12/82	43.0
25/12/82	104.0
31/12/82	74.0
6/01/83	95.0
12/01/83	214.0
18/01/83	34.0
24/01/83	33.0
30/01/83	86.0
5/02/83	50.0
11/02/83	48.0
17/02/83	47.0
23/02/83	57.0
1/03/83	25.0
7/03/83	66.0
13/03/83	39.0
19/03/83	106.0
25/03/83	66.0
31/03/83	44.0
6/04/83	59.0
12/04/83	40.0
18/04/83	112.0
24/04/83	24.0
30/04/83	42.0
6/05/83	27.0
12/05/83	49.0
18/05/83	44.0
24/05/83	84.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
5/06/83	38.0
11/06/83	41.0
17/06/83	23.0
23/06/83	26.0
29/06/83	44.0
5/07/83	51.0
11/07/83	33.0
17/07/83	35.0
23/07/83	49.0
29/07/83	33.0
4/08/83	66.0
10/08/83	37.0
16/08/83	28.0
22/08/83	50.0
28/08/83	20.0
3/09/83	30.0
9/09/83	17.0
15/09/83	43.0
21/09/83	74.0
27/09/83	38.0
3/10/83	54.0
9/10/83	54.0
15/10/83	78.0
21/10/83	30.0
27/10/83	61.0
20/11/83	12.0
26/11/83	44.0
2/12/83	54.0
8/12/83	65.0
14/12/83	37.0
20/12/83	22.0
26/12/83	40.0
1/01/84	33.0
31/01/84	120.0
6/02/84	64.0
12/02/84	56.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
18/02/84	156.0
24/02/84	29.0
1/03/84	80.0
7/03/84	76.0
13/03/84	49.0
19/03/84	102.0
25/03/84	62.0
31/03/84	59.0
6/04/84	31.0
12/04/84	33.0
18/04/84	49.0
24/04/84	32.0
30/04/84	39.0
6/05/84	26.0
12/05/84	17.0
18/05/84	35.0
24/05/84	28.0
30/05/84	54.0
5/06/84	41.0
11/06/84	43.0
17/06/84	51.0
23/06/84	32.0
29/06/84	24.0
5/07/84	44.0
11/07/84	57.0
17/07/84	62.0
23/07/84	46.0
29/07/84	45.0
10/08/84	45.0
16/08/84	65.0
22/08/84	63.0
28/08/84	29.0
3/09/84	24.0
9/09/84	22.0
15/09/84	34.0
21/09/84	45.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
27/09/84	142.0
9/10/84	56.0
15/10/84	49.0
21/10/84	52.0
27/10/84	57.0
2/11/84	49.0
8/11/84	72.0
14/11/84	93.0
20/11/84	24.0
26/11/84	102.0
2/12/84	78.0
8/12/84	115.0
14/12/84	37.0
20/12/84	64.0
26/12/84	78.0
1/01/85	10.0
7/01/85	8.0
13/01/85	35.0
25/01/85	91.0
31/01/85	91.0
6/02/85	63.0
12/02/85	32.0
18/02/85	203.0
24/02/85	56.0
2/03/85	199.0
8/03/85	187.0
14/03/85	130.0
20/03/85	85.0
26/03/85	48.0
1/04/85	61.0
7/04/85	77.0
13/04/85	77.0
19/04/85	36.0
25/04/85	49.0
6/06/85	23.0
12/06/85	89.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
18/06/85	62.0
24/06/85	57.0
30/06/85	67.0
6/07/85	52.0
12/07/85	72.0
18/07/85	14.0
24/07/85	41.0
5/08/85	22.0
11/08/85	30.0
17/08/85	31.0
23/08/85	45.0
29/08/85	53.0
4/09/85	6.0
10/09/85	42.0
16/09/85	22.0
22/09/85	27.0
28/09/85	46.0
4/10/85	53.0
10/10/85	39.0
16/10/85	41.0
22/10/85	24.0
28/10/85	30.0
3/11/85	22.0
9/11/85	19.0
15/11/85	93.0
21/11/85	59.0
27/11/85	34.0
9/12/85	24.0
15/12/85	69.0
21/12/85	68.0
27/12/85	61.0
2/01/86	32.0
8/01/86	90.0
14/01/86	51.0
20/01/86	46.0
26/01/86	32.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
1/02/86	37.0
7/02/86	173.0
13/02/86	244.0
19/02/86	31.0
25/02/86	60.0
3/03/86	205.0
9/03/86	54.0
15/03/86	115.0
21/03/86	192.0
27/03/86	162.0
2/04/86	97.0
8/04/86	197.0
14/04/86	28.0
26/04/86	48.0
2/05/86	54.0
8/05/86	68.0
26/05/86	106.0
1/06/86	84.0
7/06/86	48.0
13/06/86	70.0
19/06/86	30.0
25/06/86	75.0
1/07/86	38.0
7/07/86	55.0
13/07/86	38.0
19/07/86	53.0
25/07/86	28.0
31/07/86	52.0
6/08/86	48.0
12/08/86	38.0
18/08/86	51.0
24/08/86	26.0
30/08/86	21.0
5/09/86	20.0
11/09/86	24.0
23/09/86	50.0

Suspended Particulate Data

Castlegar; Centennial Library

Date	Total Suspended Particulate (ug/m3)
5/10/86	40.0
11/10/86	78.0
17/10/86	66.0
23/10/86	52.0
29/10/86	30.0
4/11/86	45.0
10/11/86	34.0
16/11/86	38.0
22/11/86	42.0
28/11/86	34.0
4/12/86	28.0
10/12/86	44.0
16/12/86	33.0
22/12/86	41.0
28/12/86	73.0

Suspended Particulate Data

Castlegar Hospital

Date	Total Suspended Particulate (ug/m3)
13/05/77	52.0
19/05/77	82.0
25/05/77	60.0
31/05/77	42.0
12/06/77	51.0
18/06/77	144.0
24/06/77	93.0
30/06/77	59.0
12/07/77	23.0
5/08/77	30.0
11/08/77	77.0
17/08/77	84.0
23/08/77	32.0
29/08/77	18.0
10/09/77	42.0
16/09/77	27.0
22/09/77	58.0
28/09/77	25.0
4/10/77	53.0
10/10/77	30.0
16/10/77	58.0
22/10/77	57.0
28/10/77	34.0
3/11/77	36.0
9/11/77	31.0
15/11/77	54.0
21/11/77	44.0
27/11/77	68.0
3/12/77	35.0
9/12/77	26.0
15/12/77	29.0
21/12/77	75.0
27/12/77	19.0
2/01/78	13.0
8/01/78	32.0
14/01/78	18.0

Suspended Particulate Data

Castlegar Hospital

Date	Total Suspended Particulate (ug/m3)
20/01/78	50.0
26/01/78	87.0
1/02/78	37.0
7/02/78	30.0
13/02/78	92.0
19/02/78	157.0
25/02/78	125.0
3/03/78	130.0
9/03/78	149.0
15/03/78	94.0
21/03/78	137.0
27/03/78	35.0
2/04/78	24.0
8/04/78	95.0
14/04/78	95.0
20/04/78	41.0
26/04/78	97.0
2/05/78	54.0
8/05/78	99.0
14/05/78	18.0
20/05/78	78.0
26/05/78	50.0
1/06/78	89.0
7/06/78	128.0
13/06/78	14.0
25/06/78	32.0
1/07/78	24.0
7/07/78	69.0
13/07/78	55.0
19/07/78	43.0
25/07/78	67.0
31/07/78	59.0
6/08/78	60.0
12/08/78	20.0
18/08/78	22.0
24/08/78	24.0

Suspended Particulate Data

Castlegar Hospital

Date	Total Suspended Particulate (ug/m3)
30/08/78	66.0
5/09/78	19.0
11/09/78	36.0
17/09/78	22.0
23/09/78	38.0
29/09/78	73.0
5/10/78	69.0
11/10/78	31.0
17/10/78	54.0
23/10/78	71.0
29/10/78	48.0
28/11/78	28.0
4/12/78	45.0
10/12/78	45.0
16/12/78	66.0
28/12/78	21.0
1/08/80	115.0
7/08/80	50.0
13/08/80	62.0
19/08/80	29.0
6/09/80	40.0
12/09/80	59.0
18/09/80	50.0
24/09/80	37.0
30/09/80	30.0
6/10/80	47.0



Centennial Library - Dustfall Data

Start Date	Particulate Total	Soluble	Insoluble	Particulate Ash Soluble	Insoluble	Cadmium Total	Soluble	Insoluble	Lead Total	Soluble	Insoluble	Zinc Total	Soluble	Insoluble	Sodium Soluble
	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day
2/01/75	1.30770	.98075	.32692	.28021	.08173	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.04553
3/01/75	1.01580	.77059	.24519	.05838	.23351	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.04904
2/10/75	2.48690	.17513	2.31180	.63048	.78226	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/04/75	1.00410	.37362	.63048	.50205	.52740	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.01401
1/05/75	1.45940	.45335	.73556	.19848	.73556	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/06/75	1.19090	.45335	.73556	.19848	.73556	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/10/75	.85232	.23351	.61881	.05838	.46702	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/10/75	.61881	.19848	.43200	.12843	.33859	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/08/75	.60713	.14011	.46702	.12843	.33859	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/10/75	.33859	.19848	.46702	.12843	.33859	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/10/75	.47870	.28021	.19848	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/12/75	.52540	.15178	.37362	.05838	.12843	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/01/75	.19848	.05838	.19848	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/02/76	.61881	.05838	.19848	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/01/75	.19848	.05838	.19848	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
26/02/76	1.07420	.05838	1.07420	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/04/76	.59545	.05838	.59545	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/05/76	1.08580	.05838	1.08580	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
31/05/76	.61881	.05838	.56043	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
29/06/76	.65551	.16346	.50205	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
30/08/76	1.06580	.31524	.77059	.16346	.47870	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
4/10/76	.79394	.22184	.57210	.10536	.23251	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
4/11/76	.57210	.31524	.25688	.10536	.23251	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/12/76	.35027	.12843	.22184	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/01/77	.39697	.17513	.22184	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/02/77	1.01580	.30356	.71221	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/03/77	.77059	.11676	.65383	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
28/03/77	1.30770	.16346	1.14420	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/08/77	1.52290	.16346	1.36940	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/09/77	.51373	.15178	.36194	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/10/77	.68888	.37362	.31524	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/11/77	.53708	.26194	.17513	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
6/12/77	.21016	.12843	.08173	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/01/78	.51373	.35027	.16346	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/02/78	.85232	.37362	.47870	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/03/78	.99242	.31524	.67718	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
31/03/78	1.06250	.30356	.75891	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/05/78	.57210	.10508	.46702	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/06/78	.84964	.24519	.59545	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
28/06/78	.60713	.12843	.47870	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
1/08/78	.73556	.26854	.46702	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
31/08/78	.50205	.21016	.29189	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
3/10/78	.75891	.40685	.35027	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
30/10/78	.71221	.47870	.23251	.05838	.16346	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
5/12/78	.45335	.45335	.05838	.14011	.05838	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200
2/01/79	.38528	.32692	.05838	.15178	.05838	.00100	.00012	.00012	.00117	.00117	.00117	.00234	.00117	.00117	.00200

Centennial Library - Dustfall Data

Start Date	Particulate Total	Soluble	Insoluble	Particulate Ash Soluble	Insoluble	Cadmium Total	Soluble	Insoluble	Lead Total	Soluble	Insoluble	Zinc Total	Soluble	Insoluble	Sodium Soluble
	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day
5/02/79	.9607	.6886	.2821	.11676	.63048	.00100	.00012	.00012	.00210	.00198	.00100	.00537	.00023	.00537	
2/03/79	1.07420	.33859	.7356			.00100	.00012	.00012	.00100	.00100	.00100	.00163	.00047	.00117	
2/04/79	.61881	.75686	.36194	.09341	.35027	.00100	.00012	.00012	.00100	.00100	.00100	.00117	.00035	.00082	
1/05/79	.98075	.42032	.56043			.00100	.00012	.00012	.00444	.00100	.00100	.00175	.00035	.00140	
5/06/79	.65383	.05838	.65383	.10608	.29189	.00100	.00012	.00012	.00100	.00100	.00100	.00117	.00035	.00140	
4/07/79	.94572	.28021	.66551	.10608	.29189	.00100	.00012	.00012	.00100	.00100	.00100	.00117	.00035	.00140	
31/07/79	.63048	.15178	.47870	.10608	.29189	.00100	.00012	.00012	.00100	.00100	.00100	.00117	.00035	.00140	
4/09/79	.65383	.14011	.51373	.10608	.29189	.00100	.00012	.00012	.00100	.00100	.00100	.00117	.00035	.00140	
27/09/79	.50205	.24519	.25686	.14011	.22184	.00100	.00012	.00012	.00100	.00100	.00100	.00163	.00035	.00128	
1/11/79	.56043	.29189	.26854	.05838	.53708	.00100	.00012	.00012	.00152	.00100	.00100	.00163	.00035	.00128	
4/12/79	.63048	.14011	.49037	.24519	.53708	.00100	.00012	.00012	.00105	.00100	.00100	.00163	.00035	.00128	
3/01/80	.87567	.26854	.60713	.24519	.53708	.00100	.00012	.00012	.00105	.00100	.00100	.00163	.00035	.00128	
4/02/80	.51373	.38529	.12843	.09341	.39394	.00100	.00012	.00012	.00117	.00100	.00100	.00163	.00035	.00128	
5/03/80	1.24930	.30756	.94572	.16346	4.35500	.00100	.00012	.00012	.00117	.00100	.00100	.00163	.00035	.00128	
2/04/80	.81729	.29189	.52540	.16346	4.35500	.00100	.00012	.00012	.00117	.00100	.00100	.00163	.00035	.00128	
13/05/80	.81729	.22184	.67718	.05838	.57210	.00100	.00012	.00012	.00105	.00100	.00100	.00163	.00035	.00128	
3/06/80	.81729	.14011	.67718	.05838	.57210	.00100	.00012	.00012	.00105	.00100	.00100	.00163	.00035	.00128	
3/07/80	.84064	.17513	.66551	.05838	.57210	.00100	.00012	.00012	.00105	.00100	.00100	.00163	.00035	.00128	
31/07/80	1.05080	.45535	.59545	.05838	.57210	.00100	.00012	.00012	.00234	.00210	.00100	.00163	.00035	.00128	
5/09/80	.60713	.29189	.31524	.05838	.28021	.00100	.00012	.00012	.00234	.00210	.00100	.00163	.00035	.00128	
9/10/80	.80561	.57210	.23351	.11676	.22184	.00100	.00012	.00012	.00100	.00100	.00100	.00163	.00035	.00128	
8/12/80	.61881	.37362	.24519	.09341	.22184	.00100	.00012	.00012	.00100	.00100	.00100	.00163	.00035	.00128	
6/01/81	.50205	.15178	.35027	.09341	.22184	.00100	.00012	.00012	.00100	.00100	.00100	.00163	.00035	.00128	
2/02/81	.99242	.36194	.63048	.35027	.12843	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
5/03/81	.77059	.38529	.38529	.35027	.12843	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/04/81	1.03910	.46702	.57210	.05838	.18681	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
6/05/81	.64216	.36194	.28021	.05838	.18681	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/06/81	1.03910	.38529	.65383	.14011	.35027	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
7/07/81	.98075	.30356	.67718	.11676	.24519	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
30/07/81	.51373	.10508	.40865	.11676	.24519	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
31/08/81	.53708	.24519	.29189	.11676	.24519	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
15/10/81	.34270	.78226	.46043	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
30/10/81	.71221	.29189	.42032	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
30/11/81	.40865	.21016	.19848	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
28/01/82	1.29600	.45535	.84064	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
3/03/82	1.08580	.16346	.92237	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
4/05/82	1.07420	.54875	.52540	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/06/82	.65383	.11676	.53708	.11676	.24519	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/07/82	.63048	.23351	.39697	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
3/08/82	.84064	.24519	.59545	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/09/82	.92237	.50205	.42032	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
30/09/82	.59545	.35027	.24519	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
1/11/82	.39697	.24519	.12843	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
4/01/83	.71221	.47870	.23351	.17513	.05838	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
1/02/83	.80561	.32692	.47870	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	
2/03/83	.77059	.30356	.42032	.18681	.22184	.00100	.00012	.00012	.00175	.00140	.00100	.00269	.00047	.00222	

Centennial Library - Dustfall Data

[illegible]

Castlegar Airport - Dustfall Data

[illegible]

Castlegar Airport - Dustfall Data

Start Date	Particulate Total		Particulate Ash		Cadmium		Zinc		Lead		Zinc		Sodium Soluble	
	Soluble	Insoluble	Soluble	Insoluble	Total	Soluble	Insoluble	Total	Soluble	Insoluble	Total	Soluble	Insoluble	
	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	mg/dm2/day	
1/05/79	.91069	.44367	.07005	.22184	.00100	.00012	.00012	.00257	.00117	.00140	.00152			
5/06/79	1.47110	1.03910			.00100	.00012	.00012	.00198	.00117	.00047				
4/09/79	.93405	.44367	.15178	.09341	.00100	.00012	.00012	.00354	.00100	.00023				
4/12/79	.33859	.07005	.05838	.05838	.00100	.00012	.00012	.00397	.00350	.00023				
3/01/80	.32692	.05838	.10508	.05838	.00100	.00012	.00012	.00140	.00117	.00012				
4/02/80	.42032	.05838	.05838	.08173	.00100	.00012	.00012	.00140	.00100	.00012				
6/03/80	.53708	.14011	.05838		.00100	.00012	.00012	.00100	.00100	.00035				
3/04/80	1.00410	.53708			.00100	.00012	.00012	.00100	.00100	.00012				
3/05/80	3.30420	2.86390	.14011	2.76710	.00100	.00012	.00012	.00210	.00198	.00023				
11/07/80	.94572	.28021			.00100	.00012	.00012	.00292	.00100	.00023				
1/09/80	.32692	.05838			.00100	.00012	.00012			.00012				

Sulphation Index Data

Castlegar; Centennial Library

Start Date	Sulphation Index (mg/dm ² /day)
2/01/75	.690
31/01/75	.901
27/02/75	.590
3/04/75	.240
1/05/75	.270
3/06/75	.260
27/06/75	.240
31/07/75	.150
29/08/75	.280
1/10/75	.390
30/10/75	.800
1/12/75	.860
30/12/75	.720
2/02/76	.420
26/02/76	.360
1/04/76	.260
3/05/76	.230
31/05/76	.340
29/06/76	.330
30/08/76	.220
4/10/76	.230
4/11/76	.590
2/12/76	.830
1/01/77	.610
2/02/77	.740
3/03/77	.300
28/03/77	.170
3/05/77	.290
2/06/77	.230
11/07/77	.270
2/08/77	.110
1/09/77	.210
3/10/77	.250
1/11/77	.520
6/12/77	.150
3/01/78	.200
1/02/78	.420
1/03/78	.360
31/03/78	.140
1/05/78	.220
1/06/78	.220
1/08/78	.190
31/08/78	.280

Sulphation Index Data

Castlegar; Centennial Library

Start Date	Sulphation Index (mg/dm ² /day)
3/10/78	.430
30/10/78	.780
5/12/78	1.210
2/01/79	.780
5/02/79	.530
2/03/79	.380
2/04/79	.190
1/05/79	.300
5/06/79	.180
4/07/79	.190
31/07/79	.270
4/09/79	.420
27/09/79	.250
1/11/79	.370
4/12/79	.850
3/01/80	.050
4/02/80	.360
5/03/80	.460
2/04/80	.160
13/05/80	.280
3/06/80	.200
3/07/80	.150
31/07/80	.210
5/09/80	.300
9/10/80	.420
4/11/80	.540
8/12/80	.720
6/01/81	.190
2/02/81	.320
5/03/81	.140
2/04/81	.170
2/06/81	.120
7/07/81	.190
30/07/81	.110
31/08/81	.110
15/10/81	.440
30/10/81	.430
7/01/82	.180
3/03/82	.240
4/05/82	.100
2/06/82	.060
2/07/82	.060
3/08/82	.120

Sulphation Index Data

Castlegar; Centennial Library

Start Date	Sulphation Index (mg/dm ² /day)
2/09/82	.130
30/09/82	.352
1/11/82	.480
1/12/82	2.060
4/01/83	1.400
1/02/83	.760
2/03/83	.220
5/04/83	.100
2/05/83	.160
1/06/83	.140
4/07/83	.200
3/08/83	.080
1/09/83	.150
3/10/83	.270
31/10/83	.330
1/12/83	.830
4/01/84	.840
1/02/84	.410
2/03/84	.170
3/05/84	.130
1/06/84	.090
3/07/84	.170
1/08/84	.170
1/10/84	.320
1/11/84	.360
3/12/84	.810
7/01/85	.390
5/02/85	1.010
1/03/85	.070
3/04/85	.250
2/05/85	.260
3/06/85	.160
2/07/85	.120
1/08/85	.130
3/09/85	.160
1/10/85	.420
2/12/85	.970
2/01/86	.400
3/02/86	.250
3/03/86	.210
1/04/86	.110
1/05/86	.140
2/06/86	.150

Sulphation Index Data

Castlegar; Centennial Library

Start Date	Sulphation Index (mg/dm ² /day)
30/06/86	.170
11/08/86	.130
1/10/86	.150
3/11/86	.310
1/12/86	.590

Sulphation Index Data

Castlegar Airport

Start Date	Sulphation Index (mg/dm ² /day)
29/01/75	2.212
3/03/75	1.100
3/04/75	.420
1/05/75	.360
3/06/75	.420
27/06/75	.340
31/07/75	.140
29/08/75	.310
1/10/75	.670
30/10/75	2.000
1/12/75	2.550
30/12/75	1.470
2/02/76	1.150
26/02/76	.600
1/04/76	.350
3/05/76	.240
31/05/76	.330
29/06/76	.440
28/07/76	.260
4/10/76	.520
2/11/76	.930
1/12/76	2.180
7/01/77	1.420
2/02/77	1.300
3/03/77	.560
30/03/77	.250
3/05/77	.590
2/06/77	.020
11/07/77	.790
2/08/77	.100
1/09/77	.520
3/10/77	.500
1/11/77	1.420
6/12/77	.460
3/02/78	1.190
9/03/78	.830
31/03/78	.470
1/05/78	.320
28/06/78	.390
1/08/78	.204
31/08/78	.690
3/10/78	.834
30/10/78	1.540

Sulphation Index Data

Castlegar Airport

Start Date	Sulphation Index (mg/dm ² /day)
5/12/78	3.020
2/01/79	1.750
5/02/79	1.700
2/03/79	.890
5/04/79	.370
1/05/79	.320
5/06/79	.300
4/07/79	.220
1/08/79	.450
4/09/79	.580
27/09/79	.470
1/11/79	.800
4/12/79	2.100
3/01/80	.720
4/02/80	.940
3/04/80	.240
13/05/80	.580
3/06/80	.400
3/07/80	.200
31/07/80	.410
5/09/80	.020

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

1975

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	2.04	1.49	1.14	0.40	0.17	0.25	0.54	0.10	0.15	0.44	1.02	1.53
Blueberry Creek	1.20	0.94	0.55	0.28	0.10	0.17	0.16	0.05	0.12	0.27	0.67	1.06
China Creek	1.25	1.09	0.67	0.28	0.07	0.15	0.16	0.02	0.15	0.23	0.74	0.97
Genelle	1.81	1.29	0.60	0.36	0.17	0.15	0.22	0.07	0.17	0.31	0.89	1.16
Birchbank	1.02	0.94	0.55	0.20	0.07	0.17	0.12	0.02	0.12	0.23	0.45	0.72
Birchbank Golf Course	1.53	0.84	0.55	0.40	0.14	0.27	0.20	0.07	0.12	0.35	0.87	1.85
Oasis	2.22	1.49	1.04	0.71	0.38	0.40	0.40	0.12	0.25	0.66	1.44	1.39
Rivervale	-	0.91	0.45	0.46	0.17	0.26	0.31	0.12	0.22	0.39	0.92	1.21
Tadanac (Nurseries)	1.12	0.17	0.94	0.46	0.37	0.47	-	-	0.32	0.33	0.60	0.69
M.K.P. & L. Bldg	0.85	0.94	0.77	0.73	0.65	0.84	0.99	0.26	0.77	0.85	0.74	0.86
Glenmerry	0.45	0.87	0.84	0.40	0.25	0.36	0.39	0.20	0.32	0.32	0.28	0.44
Pollution Centre	0.76	1.24	0.74	0.65	0.23	0.42	0.59	0.12	0.75	0.75	0.56	0.65
Columbia Gardens	0.78	1.59	0.99	0.29	0.19	0.32	0.29	0.07	0.39	0.64	0.32	0.65
Waneta	0.67	1.04	0.84	0.33	0.14	0.20	0.33	0.09	0.28	0.58	0.30	0.56

1976

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	1.26	1.69	0.94	0.57	-	0.31	0.25	0.20	-	0.35	0.86	1.79
Blueberry Creek	0.76	0.92	0.42	0.50	0.10	0.40	0.29	0.15	0.25	-	0.44	1.43
China Creek	0.76	1.12	0.45	0.50	0.02	0.65	-	0.12	0.20	0.22	0.55	1.31
Genelle	0.88	1.24	0.64	0.28	0.12	0.52	0.17	0.10	0.20	0.29	0.52	1.52
Birchbank	0.55	0.60	0.45	0.28	0.05	0.34	0.09	0.10	0.30	0.18	0.46	1.03
Birchbank Golf Course	1.52	1.56	0.69	0.32	0.15	0.30	0.16	0.27	0.15	0.24	0.65	1.03
Oasis	1.09	1.81	1.29	0.79	0.25	0.46	0.42	0.17	0.32	0.43	0.97	1.99
Rivervale	1.08	0.97	0.89	0.54	0.22	0.29	0.25	0.10	0.25	0.35	0.65	1.07
Tadanac (Nurseries)	0.63	0.69	0.42	0.30	0.05	0.15	0.25	0.12	0.29	0.29	0.34	0.44
M.K.P. & L. Bldg	0.88	0.69	0.69	0.79	0.32	0.14	0.49	0.17	0.60	0.69	0.46	0.44
Glenmerry	0.34	0.45	0.55	0.38	0.15	0.26	0.28	0.25	0.55	0.61	0.32	0.28
Pollution Centre	0.74	0.35	0.42	0.65	0.22	0.31	0.31	0.17	0.72	0.65	0.53	0.28
Columbia Gardens	0.48	0.45	0.35	0.31	0.27	0.58	0.18	0.17	0.48	0.57	0.48	0.20
Waneta	0.35	0.30	0.37	0.15	0.15	0.17	0.14	0.20	0.41	0.45	0.34	0.20

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

1977

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	1.44	1.09	-	0.21	0.34	0.26	0.18	-	0.37	0.55	0.77	1.00
Blueberry Creek	0.84	0.69	0.36	0.19	0.24	0.21	0.12	0.02	0.16	0.38	0.46	-
China Creek	0.84	0.64	0.28	0.19	0.26	0.21	0.12	0.02	0.24	0.31	0.44	0.58
Genelle	0.92	0.72	0.36	0.19	0.26	0.23	0.16	0.02	0.27	0.31	0.57	0.58
Birchbank	0.74	0.62	0.36	0.22	0.23	0.18	0.12	0.02	0.16	0.29	0.33	0.37
Birchbank Golf Course	1.56	1.24	0.57	0.20	0.32	0.31	0.20	0.02	0.37	0.55	0.75	1.16
Oasis	1.29	1.49	0.89	0.36	0.65	0.36	0.24	0.02	0.49	0.86	0.87	1.12
Rivervale	0.67	0.79	0.47	0.20	0.42	0.36	0.20	0.07	0.39	0.50	0.64	0.75
Tadanac (Nurseries)	0.27	0.50	0.35	0.35	0.40	0.35	0.24	0.02	0.39	0.53	0.40	0.38
W.K.P. & L. Bldg	0.52	0.86	0.50	0.63	0.74	0.72	0.40	0.35	0.84	0.62	0.57	0.34
Glennerry	0.27	0.62	0.32	0.45	0.49	0.64	0.34	0.07	0.45	0.62	0.46	0.33
Pollution Centre	0.28	0.72	0.39	0.51	0.47	0.59	0.26	0.17	0.51	0.67	0.52	0.52
Columbia Gardens	0.27	0.74	0.36	0.33	0.32	0.41	0.18	0.07	0.39	0.41	0.52	0.48
Maneta	0.20	0.57	0.28	0.27	0.22	0.43	0.20	0.10	0.39	0.34	0.52	0.40

1978

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.94	1.24	0.44	0.30	0.20	0.24	0.30	0.02	0.22	0.30	0.87	1.67
Blueberry Creek	-	0.47	0.64	0.25	0.20	0.39	0.30	-	0.08	0.22	0.67	0.95
China Creek	0.64	0.82	0.60	0.22	0.17	0.22	0.25	0.05	0.18	0.30	0.84	1.51
Genelle	0.62	0.84	0.64	0.40	0.15	0.22	0.22	0.07	0.08	0.32	0.97	1.76
Birchbank	0.45	0.55	0.52	0.25	0.12	0.12	0.20	0.02	0.12	0.25	0.74	0.95
Birchbank Golf Course	0.94	0.94	0.74	0.62	0.17	0.33	0.40	0.05	0.20	0.30	1.04	1.82
Oasis	0.97	0.94	0.93	0.57	0.42	0.55	0.59	0.10	0.34	0.47	1.29	2.12
Rivervale	0.64	0.67	0.62	0.50	0.40	0.33	0.37	0.09	0.22	0.32	0.94	1.21
Tadanac (Nurseries)	0.40	0.42	0.58	0.32	0.30	0.27	0.45	0.07	0.26	0.40	0.67	0.79
W.K.P. & L. Bldg	0.79	0.69	0.87	0.79	0.57	0.76	0.72	0.25	0.34	0.52	0.99	0.67
Glennerry	0.79	0.64	0.22	0.69	0.45	0.49	0.50	0.22	0.18	0.40	0.74	0.44
Pollution Centre	1.31	0.79	1.07	1.02	0.46	0.53	0.64	0.22	0.30	0.50	0.67	0.34
Columbia Gardens	1.56	1.06	0.95	0.72	0.35	0.33	0.35	0.15	0.24	0.37	0.52	0.28
Maneta	1.31	0.84	0.79	0.50	0.35	0.31	0.32	0.02	0.20	0.35	0.64	0.20

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

1979

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.64	1.17	0.69	0.22	0.10	0.20	-	0.24	0.40	0.25	0.54	1.6
Blueberry Creek	0.67	0.92	0.70	0.22	0.04	0.10	0.05	0.12	0.20	0.22	0.34	0.9
China Creek	0.87	1.19	0.61	0.37	0.12	0.12	0.15	0.20	0.27	0.32	0.52	1.4
Genelle	0.94	1.11	0.63	0.27	0.18	0.15	0.05	0.20	0.35	0.37	0.54	1.6
Birchbank	0.69	0.80	0.54	0.30	0.14	0.15	0.02	0.10	0.20	0.17	0.40	0.71
Birchbank Golf Course	0.92	1.30	0.64	0.40	0.20	0.20	0.07	0.16	0.32	0.35	0.64	1.7
Oasis	1.24	0.80	1.05	0.97	0.36	0.55	0.15	0.36	0.52	0.57	0.95	2.1
Rivervale	0.89	0.81	0.56	0.55	0.28	0.15	0.15	0.24	0.47	0.50	0.66	1.1
Tadanac (Nurseries)	0.50	0.12	0.49	0.55	0.28	0.45	0.20	0.46	0.50	0.40	0.44	0.87
W.K.P. & L. Bldg	0.97	0.35	0.90	-	0.56	0.69	0.64	0.48	0.87	0.85	0.79	0.73
Glenmerry	0.97	1.11	0.83	0.52	0.52	0.32	0.27	0.28	0.60	0.62	0.54	0.44
Pollution Centre	0.84	0.70	0.86	0.50	0.66	0.37	0.37	0.50	0.72	0.70	0.66	0.40
Columbia Gardens	0.84	0.76	0.64	0.35	0.50	0.30	0.30	0.38	0.60	0.47	0.68	0.67
Maneta	0.64	0.68	0.51	0.27	0.32	0.15	0.30	0.30	0.52	0.47	0.50	-

1980

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.40	0.74	0.46	0.51	0.16	0.17	0.21	0.32	0.27	0.45	0.64	1.53
Blueberry Creek	0.36	0.42	0.38	0.02	0.08	0.09	0.07	0.12	0.14	0.29	0.58	0.99
China Creek	0.44	0.60	0.41	0.12	0.15	0.25	0.07	0.17	0.26	0.41	0.67	1.63
Genelle	0.48	0.60	0.31	0.29	0.19	0.24	0.15	0.25	0.27	0.40	0.68	1.29
Birchbank	0.32	0.37	0.38	0.24	0.16	0.10	0.09	0.20	0.15	0.32	0.61	0.73
Birchbank Golf Course	0.54	0.52	0.70	0.31	0.41	0.31	0.17	0.27	0.05	0.51	0.97	1.53
Oasis	0.77	1.02	1.22	0.61	0.59	0.55	0.27	0.52	0.55	0.94	1.22	2.30
Rivervale	0.46	-	0.79	0.41	0.36	0.43	0.25	0.39	0.55	0.53	0.65	1.11
Tadanac (Nurseries)	0.34	0.52	0.53	0.41	0.30	0.37	0.29	0.50	0.13	0.43	0.33	0.48
W.K.P. & L. Bldg	0.87	0.77	0.34	0.96	0.82	0.50	0.93	1.14	0.92	0.84	0.40	0.68
Glenmerry	0.65	0.60	0.43	0.57	0.44	0.37	0.56	0.52	0.34	0.57	0.42	0.52
Pollution Centre	0.67	0.69	0.36	0.69	0.52	0.37	0.54	0.44	0.32	0.49	0.33	0.68
Columbia Gardens	0.81	1.44	0.29	0.33	0.48	0.27	0.42	0.36	0.28	0.26	0.45	0.99
Maneta	0.87	1.71	0.36	0.55	0.46	0.21	0.44	0.29	-	0.49	0.36	0.99

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

1981

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.36	0.55	0.09	0.27	0.19	0.33	0.29	0.19	0.21	0.36	0.14	0.92
Blueberry Creek	0.32	0.43	0.14	0.24	0.16	0.18	0.17	0.16	0.18	0.24	0.18	0.73
China Creek	0.37	0.55	0.17	0.29	0.21	0.12	0.21	0.19	0.18	0.35	0.67	0.92
Genelle	0.38	0.60	0.13	0.25	0.20	0.22	0.25	0.24	0.27	0.43	0.45	0.86
Birchbank	0.43	0.48	0.09	0.29	0.18	0.20	0.17	0.16	0.17	0.24	0.55	0.73
Birchbank Golf Course	0.44	-	0.17	0.38	0.33	0.33	0.23	0.23	0.31	0.23	0.57	0.90
Dasis	0.50	0.98	-	0.57	0.43	0.47	0.46	0.34	0.38	0.27	0.57	1.12
Rivervale	0.38	0.67	0.97	0.45	0.32	0.41	0.35	0.29	0.36	0.37	0.47	0.55
Tadanac (Nurseries)	0.15	0.17	0.30	0.23	-	0.46	0.63	0.36	0.41	0.38	0.67	0.96
W.K.P. & L. Bldg	0.93	0.82	0.69	0.45	0.65	0.57	1.07	1.03	0.77	0.67	1.03	0.86
Glenmerry	0.84	0.62	0.77	0.21	0.32	0.34	0.67	0.67	0.58	0.50	0.74	0.51
Pollution Centre	0.74	0.48	0.62	0.24	0.42	0.38	0.77	0.82	0.60	0.63	0.67	0.59
Columbia Gardens	1.20	0.87	0.07	0.35	0.28	0.34	0.61	0.69	0.15	0.38	0.77	0.60
Maneta	1.65	1.23	0.69	0.31	0.40	0.29	0.52	0.62	0.46	0.55	0.93	0.73

1982

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	1.24	1.25	0.38	0.33	0.15	0.22	0.04	0.16	0.26	0.52	0.57	1.24
Blueberry Creek	0.98	0.89	0.43	0.28	0.13	0.21	0.07	0.17	0.15	0.26	0.39	0.66
China Creek	1.29	0.93	0.50	0.31	0.17	0.21	0.06	0.12	0.23	0.36	0.59	0.84
Genelle	1.08	1.00	0.57	0.31	0.04	0.28	0.06	0.25	0.14	0.44	0.82	1.19
Birchbank	1.05	0.73	0.34	0.27	0.16	0.23	0.02	0.17	0.19	0.28	0.55	0.57
Birchbank Golf Course	1.15	1.23	0.52	0.42	0.17	0.50	0.04	0.16	0.31	0.50	0.78	0.93
Dasis	1.32	1.89	1.03	0.67	0.37	0.44	0.04	0.29	0.49	0.68	1.25	1.19
Rivervale	0.60	0.71	0.41	0.31	0.17	0.24	0.04	0.23	0.29	0.45	0.52	0.63
Tadanac (Nurseries)	0.84	1.00	0.59	0.57	0.37	0.43	0.02	0.22	0.44	0.80	0.66	0.77
W.K.P. & L. Bldg	0.74	0.87	-	0.57	0.44	0.80	0.31	1.04	0.75	0.84	0.96	0.97
Glenmerry	0.62	0.52	0.52	0.31	0.57	0.59	0.11	0.77	0.49	0.71	0.71	0.66
Pollution Centre	0.65	0.52	0.59	0.44	0.62	0.55	0.14	0.75	0.49	0.78	0.48	0.58
Columbia Gardens	0.86	0.43	0.59	0.34	0.45	0.52	0.14	0.73	0.53	0.73	0.64	0.58
Maneta	0.98	0.46	0.55	0.29	0.44	0.17	0.29	0.85	0.57	0.98	0.82	0.77

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

1983

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.15	0.75	0.38	0.11	0.13	0.20	0.26	0.03	0.09	0.39	0.41	0.71
Blueberry Creek	1.07	0.46	0.23	0.07	0.07	0.11	0.06	0.04	0.07	0.23	0.27	0.42
China Creek	1.23	0.52	0.26	0.09	0.15	0.17	0.07	0.03	0.16	0.34	0.34	0.57
Genelle	1.46	0.66	0.38	0.14	0.14	0.22	0.20	0.04	0.14	0.18	0.42	0.7
Birchbank	0.82	0.37	0.27	0.09	0.14	0.04	0.11	0.06	0.09	0.33	0.27	0.41
Birchbank Golf Course	1.41	0.66	0.42	0.17	0.22	0.23	0.30	0.04	0.23	0.77	0.70	0.88
Oasis	1.48	0.98	0.64	0.33	0.32	0.33	0.43	0.09	0.40	0.80	0.71	0.62
Rivervale	0.75	0.41	0.27	0.25	0.19	0.14	0.24	0.01	0.27	0.48	0.42	0.20
Tadanac (Nurseries)	1.09	0.50	0.35	0.27	0.26	0.38	0.48	0.07	0.36	0.43	0.62	0.28
W.K.P. & L. Bldg	0.91	0.59	0.62	0.55	0.47	0.39	0.62	0.15	0.75	0.89	0.58	0.45
Glenmerry	0.68	0.36	0.44	0.40	0.28	0.24	0.26	0.19	0.51	0.80	0.47	0.49
Pollution Centre	0.57	0.52	0.62	0.43	0.24	0.24	0.32	0.16	0.46	0.50	0.57	0.45
Columbia Gardens	0.87	0.73	0.62	0.38	0.14	0.18	0.26	0.07	0.47	-	0.13	-
Maneta	0.98	0.80	0.60	0.40	0.10	0.09	0.21	0.04	0.44	0.27	1.01	0.47

1984

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.88	0.76	0.40	0.06	0.20	0.24	0.33	0.30	0.31	0.41	0.38	0.96
Blueberry Creek	0.71	0.69	0.23	0.14	0.17	0.01	0.04	0.16	0.18	0.14	0.23	0.91
China Creek	0.85	0.73	0.35	0.06	0.22	0.12	0.08	0.21	0.27	0.30	0.24	0.96
Genelle	0.85	0.81	0.38	0.06	0.26	0.13	0.03	0.28	0.40	0.57	0.35	0.98
Birchbank	0.69	0.59	0.25	0.05	0.23	0.10	0.14	0.23	0.28	0.44	0.14	0.91
Birchbank Golf Course	0.87	0.83	0.51	0.10	0.29	0.08	0.16	0.30	0.40	0.66	0.45	1.01
Oasis	0.94	0.90	0.53	0.17	0.38	0.10	0.26	0.46	0.64	0.88	0.44	0.96
Rivervale	0.18	0.47	0.11	0.11	0.25	0.18	0.14	0.31	0.41	0.41	0.15	0.65
Tadanac (Nurseries)	0.85	0.21	0.20	0.20	0.40	0.26	0.26	0.49	0.52	0.64	0.30	0.83
W.K.P. & L. Bldg	0.15	0.29	0.19	0.34	0.45	0.44	0.19	0.30	1.00	0.66	0.32	0.57
Glenmerry	0.50	0.45	0.16	0.22	0.32	0.38	0.47	0.63	1.00	0.52	0.20	0.48
Pollution Centre	0.16	0.35	0.20	0.22	0.33	0.29	0.33	0.49	0.64	0.33	0.26	0.36
Columbia Gardens	0.11	0.47	0.14	0.11	0.35	0.26	0.25	-	0.83	0.27	0.35	0.41
Maneta	0.11	0.50	0.11	0.10	0.30	0.20	0.24	0.38	0.76	0.18	0.29	0.41

Cominco Ltd. Sulphation Rate Data

Note: units are mg/dm²/day

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Station	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Castlegar Airport	0.53	0.83	0.46	0.50	0.24	0.26	0.12	0.30	0.30	0.74	0.66	1.10
Blueberry Creek	0.40	0.76	0.39	0.29	0.16	0.12	0.16	0.22	0.20	0.53	0.69	1.17
China Creek	0.72	0.81	0.46	0.39	0.25	0.11	0.15	0.28	0.23	0.49	0.66	1.05
Genelle	0.44	0.81	0.50	0.47	0.30	0.20	0.15	0.31	0.32	0.74	0.76	1.19
Birchbank	0.46	0.62	0.35	0.35	0.11	0.17	0.08	0.23	0.19	0.38	0.52	0.85
Birchbank Golf Course	0.64	0.73	0.66	0.59	0.36	0.24	0.11	0.38	0.34	1.10	1.47	1.39
Oasis	0.64	0.83	0.69	0.69	0.42	0.25	0.15	0.30	0.62	0.97	1.09	1.23
Rivervale	0.30	0.66	0.50	0.40	0.09	0.07	0.09	0.29	0.27	0.61	0.18	0.64
Tadanac (Nurseries)	0.29	0.71	0.57	0.52	0.32	0.26	0.17	0.38	0.50	0.70	0.52	0.50
W.K.P. & L. Bldg	0.42	0.46	0.69	0.31	0.51	0.50	0.44	0.57	0.81	0.55	0.46	0.57
Glenmerry	0.38	0.33	0.41	0.39	0.49	0.29	0.42	0.40	0.78	0.44	0.55	0.69
Pollution Centre	0.40	0.30	0.45	0.41	0.45	0.29	0.34	0.37	0.59	0.35	0.41	0.62
Columbia Gardens	0.57	0.55	0.37	0.30	0.42	0.24	0.25	0.27	0.50	0.37	0.44	0.55
Waneta	0.51	0.57	0.48	0.28	0.36	0.34	0.22	0.24	0.52	0.49	0.46	0.62

Appendix II

Emission Data



Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
84 05 04	69	140	16
05	71	122	5
06		>150	14
07		>150	67
08		>150	11
09		>150	44
10	66	150	9
11		>150	14
12		>150	84
13		>150	27
14		>150	21
15	14	>150	0
16		>150	0
17	51	149	5
18	55	146	3
19	18	96	5
20		>150	10
21		>150	71
22		>150	0
23	42	117	0
24		>150	18
25		>150	32
26		>150	22
27		>150	15
28	99	>150	24
29		>150	12
30	Analyser Down		
31		>150	12
84 06 01	51	132	19
02		>150	0
03		>150	18
04		>150	>150
05		>150	3
06		>150	49
07		>150	85
08		>150	3
09		>150	6
10		>150	49
11		>150	12
12	17	150	3
13	14	33	4
14		>150	5
15		>150	5
16		>150	31
17		>150	20
18		>150	39
19		>150	2
20		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
84 06 21		>150	0
22	29	134	5
23	24	140	0
24	0	2	0
25	11	94	0
26	0	58	0
27	2	11	0
28	14	42	4
29	25	137	0
30	14	71	3
84 07 01		>150	0
02	Mill Down		
03	12	105	0
04	1	3	0
05	3	9	0
06		>150	0
07		>150	26
08		>150	12
09		>150	11
10		>150	20
11		>150	4
12		>150	6
13	62	>150	8
14	10	118	0
15	16	53	0
16		>150	14
17		>150	3
18		>150	20
19		>150	52
20		>150	74
21	8	141	0
22	3	10	0
23		>150	7
24		>150	13
25		>150	12
26		>150	22
27		>150	13
28		>150	23
29	52	139	16
30		>150	14
31		>150	31
84 08 01		>150	124
02		>150	11
03		>150	18
04		>150	53
05		>150	>150
06		>150	45

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
84 08 07		>150	91
08		>150	3
09		>150	4
10		>150	24
11		>150	28
12		>150	25
13		>150	11
14		>150	33
15		>150	0
16		>150	33
17		>150	19
18		>150	0
19		>150	0
20		>150	15
21		>150	21
22		>150	8
23		>150	11
24		>150	0
25		>150	21
26		>150	0
27		>150	0
28	Analyser Down		
29	42	138	19
30		>150	19
31		>150	24
84 09 01	53	140	23
02	Mill Down		
03	Mill Down		
04	Mill Down		
05	Mill Down		
06	Mill Down		
07	Mill Down		
08		>150	0
09	16	55	0
10	2	8	0
11	25	>150	0
12	4	22	0
13	25	120	0
14		>150	0
15	45	>150	0
16	22	>150	0
17	40	>150	0
18		>150	12
19		>150	29
20	76	>150	0
21		>150	12
22	24	59	0
23	44	107	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
84 09 24		>150	0
25		>150	0
26	17	>150	0
27		>150	15
28		>150	20
29		>150	36
30		>150	30
84 10 01		>150	24
02		>150	0
03		>150	20
04		>150	34
05		>150	35
06		>150	0
07		>150	24
08		>150	0
09		>150	0
10		>150	24
11	Analyser Down		
12		>150	0
13	57	>150	0
14	61	>150	13
15		>150	0
16		>150	21
17		>150	20
18		>150	>150
19		>150	0
20		>150	0
21		>150	0
22	31	>150	0
23	17	65	0
24	58	>150	0
25		>150	0
26		>150	0
27		>150	0
28		>150	13
29	11	131	0
30	14	109	0
31	10	28	0
84 11 01	21	>150	6
02	Analyser Down		
03	Analyser Down		
04	Analyser Down		
05	Analyser Down		
06	26	99	0
07	17	106	0
08	42	124	3
09	53	104	7

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
84 11 10	Analyser Down		
11	Analyser Down		
12		>150	>150
13		>150	11
14	30	>150	6
15	49	>150	6
16	40	>150	0
17		>150	3
18	43	>150	6
19	41	>150	4
20		>150	29
21	Analysr Down		
22	32	86	0
23	28	111	4
24	18	105	6
25	58	>150	0
26	74	147	4
27		>150	10
28		>150	11
29		>150	16
30		>150	3
84 12 01	12	109	06
02	15	33	5
03	33	>150	4
04		>150	4
05	53	149	13
06	6	89	0
07	16	>150	0
08		>150	0
09		>150	8
10		>150	0
11	7	28	0
12		>150	3
13		>150	0
14		>150	10
15		>150	27
16		>150	0
17	Analysr Down		
18	Analysr Down		
19	Analysr Down		
20	Analysr Down		
21	Analysr Down		
22	Analysr Down		
23	Analysr Down		
24	Analysr Down		
25	Analysr Down		
26	Analysr Down		
27	Analysr Down		

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
28	Analyser Down		
29	Analyser Down		
30	Analyser Down		
31	Analyser Down		
85 01 01	Analyser Down		
02	Analyser Down		
03	Analyser Down		
04	Analyser Down		
05	Analyser Down		
06	Analyser Down		
07	Analyser Down		
08	3	43	0
09	26	23	0
10	Analyser Down		
11	9	40	0
12	11	48	0
13		>150	0
14	Analyser Down		
15		>150	0
16		>150	11
17		>150	4
18		>150	0
19		>150	4
20		>150	14
21	19	>150	0
22	23	>150	0
23	39	115	0
24	22	122	0
25	40	150	8
26	12	104	0
27	14	64	0
28	7	28	0
29	54	119	8
30	45	>150	7
31	52	>150	17
85 02 01	53	>150	10
02		>150	26
03		>150	0
04	Analyser Down		
05	16	108	0
06		>150	0
07	8	64	0
08		>150	0
09	48	>150	0
10		>150	0
11		>150	>150
12		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 02 13	3	23	0
14	7	35	0
15	50	>150	0
16		>150	26
17		>150	21
18		>150	21
19	45	>150	5
20		>150	30
21		>150	8
22		>150	32
23		>150	0
24		>150	4
25		>150	31
26	37	>150	0
27		>150	4
28		>150	0
85 03 01		>150	62
02		>150	42
03		>150	68
04		>150	0
05		>150	>150
06		>150	21
07		>150	77
08		>150	8
09		>150	58
10		>150	0
11		>150	>150
12		>150	4
13		>150	0
14		>150	4
15		>150	0
16	Analysers Down		
17	Analysers Down		
18	15	56	6
19		>150	4
20		>150	>150
21		>150	0
22		>150	0
23		>150	>150
24		>150	77
25		>150	0
26		>150	0
27	15	>150	0
28	4	42	0
29	4	67	0
30	7	38	0
31	5	58	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 04 01	7	86	0
02	8	60	0
03	3	7	0
04	4	17	0
05		>150	>150
06		>150	63
07		>150	2
08	Mill Down		
09	Mill Down		
10	Mill Down		
11	Mill Down		
12	Mill Down		
13	Analyser Down		
14	Analyser Down		
15	Analyser Down		
16	Analyser Down		
17		>150	88
18		>150	69
19		>150	51
20	Analyser Down		
21	22	80	0
22	Analyser Down		
23	Analyser Down		
24	104	131	53
25	116	148	40
26	112	>150	40
27	90	147	29
28	96	>150	32
29	111	>150	10
30	115	>150	34
85 05 01	128	>150	38
02	96	>150	35
03	119	>150	44
04	70	124	12
05	40	113	12
06		>150	17
07	94	>150	38
08	137	>150	56
09	126	>150	52
10	100	>150	41
11	119	>150	59
12	91	>150	40
13		>150	36
14		>150	43
15		>150	114
16		>150	31
17	Analyser Down		
18		>150	>150

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 05 19		>150	>150
20		>150	>150
21		>150	>150
22		>150	27
23		>150	>150
24		>150	>150
25		>150	>150
26		>150	>150
27		>150	>150
28		>150	>150
29		>150	8
30	Analyser Down		
31	Analyser Down		
85 06 01		>150	75
02		>150	>150
03		>150	>150
04		>150	>150
05		>150	24
06		>150	67
07		>150	>150
08	No Test		
09	No Test		
10		>150	58
11		>150	110
12		>150	>150
13		>150	>150
14		>150	51
15	No Test		
16	No Test		
17		>150	>150
18		>150	>150
19		>150	>150
20		142	20
21		>150	51
22	No Test		
23	No Test		
24		>150	>150
25		>150	>150
26		>150	>150
27		>150	135
28		>150	>150
29	No Test		
30	No Test		
85 07 01	Mill Down		
02	Mill Down		
03		>150	83
04		>150	>150

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 07 05		>150	144
06	No Test		
07	No Test		
08		>150	>150
09		>150	>150
10		>150	34
11		>150	40
12		>150	>150
13	Analyser Down		
14	Analyser Down		
15		>150	66
16		>150	51
17		>150	6
18	Analyser Down		
19	Analyser Down		
20		>150	>150
21		>150	>150
22		>150	0
23		>150	>150
24		>150	0
25		>150	>150
26		>150	0
27		>150	>150
28		>150	>150
29		>150	22
30		>150	0
31		>150	0
85 08 01		>150	>150
02		>150	44
03		>150	29
04		>150	0
05		>150	0
06		>150	>150
07		>150	0
08		>150	>150
09		>150	22
10	24	>150	0
11		>150	0
12		>150	>150
13		>150	0
14		>150	36
15		>150	0
16	Mill Down		
17	Mill Down		
18	Mill Down		
19	Mill Down		
20	Mill Down		
21	Mill Down		

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 08 22	Mill Down		
23	Mill Down		
24	Mill Down		
25	Mill Down		
26	Mill Down		
27	Mill Down		
28	Mill Down		
29	Mill Down		
30	Mill Down		
31	Mill Down		
85 09 01	Mill Down		
02	Mill Down		
03	Mill Down		
04	Mill Down		
05	Mill Down		
06	Mill Down		
07	Mill Down		
08	Mill Down		
09	Mill Down		
10	Mill Down		
11		>150	6
12		>150	0
13		>150	0
14	7	41	0
15		>150	0
16		>150	69
17		>150	0
18		>150	0
19		>150	48
20		>150	0
21		>150	0
22		>150	23
23		>150	34
24		>150	43
25		>150	65
26		>150	62
27		>150	0
28		>150	32
29		>150	32
30		>150	0
85 10 01		>150	0
02		>150	0
03		>150	0
04		>150	0
05		>150	47
06		>150	0
07		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler; TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 10 08	43	>150	0
09	21	125	0
10	24	127	0
11	9	72	0
12	22	64	0
13		>150	0
14		>150	>150
15		>150	35
16	6	148	0
17	3	41	0
18		>150	0
19		>150	0
20		>150	37
21		>150	0
22		>150	46
23		>150	0
24	98	>150	0
25	62	>150	0
26	52	>150	0
27		>150	0
28	120	>150	0
29	Mill Down		
30		>150	0
31	47	>150	0
85 11 01	27	>150	0
02	39	136	0
03		>150	0
04	139	>150	0
05		>150	0
06	64	>150	0
07		>150	30
08	147	>150	0
09	37	>150	0
10	104	>150	0
11		>150	0
12		>150	0
13		>150	0
14	95	>150	0
15		>150	0
16		>150	0
17		>150	0
18		>150	91
19		>150	0
20	88	>150	0
21		>150	0
22		>150	23
23		>150	91
24		>150	>150

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
85 11 25		>150	0
26		>150	0
27	Analyser Down		
28	Analyser Down		
29	Analyser Down		
30		>150	0
31		>150	0
85 12 01		>150	>150
02	Analyser Down		
03		>150	0
04		>150	0
05		>150	>150
06	55	>150	0
07		>150	0
08		>150	0
09		>150	0
10		>150	79
11		>150	>150
12		>150	0
13		>150	0
14		>150	0
15		>150	0
16		>150	>150
17		>150	>150
18		>150	0
19	Analysers Down		
20		>150	70
21		>150	46
22		>150	0
23		>150	30
24	Mill Down		
25	Mill Down		
26	Mill Down		
27	Mill Down		
28	Mill Down		
29	Mill Down		
30	Mill Down		
31	Mill Down		
86 01 01	Analyser Down		
02	Analyser Down		
03	Analyser Down		
04		>150	0
05		>150	0
06		>150	>150
07		>150	0
08		>150	0
09		>150	>150

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 01 10		>150	>150
11		>150	51
12		>150	56
13		>150	>150
14		>150	>150
15		>150	73
16		>150	45
17		>150	0
18		>150	>150
19		>150	0
20		>150	36
21		>150	42
22		>150	>150
23		>150	>150
24		>150	47
25		>150	42
26		>150	44
27		>150	10
28		>150	>150
29		>150	>150
30		>150	0
31		>150	0
86 02 01		>150	>150
02		>150	0
03		>150	0
04		>150	0
05		>150	0
06		>150	>150
07		>150	>150
08		>150	108
09		>150	0
10		>150	0
11		>150	0
12		>150	0
13	Analyser Down		
14		>150	0
15		>150	0
16		>150	0
17	59	>150	0
18	7	112	0
19		>150	0
20		>150	0
21		>150	0
22	27	>150	0
23	0	0	0
24		>150	0
25		>150	0
26		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 02 27		>150	0
28		>150	0
86 03 01		>150	99
02		>150	0
03		>150	78
04		>150	0
05		>150	0
06		>150	>150
07		>150	0
08		>150	0
09		>150	>150
10		>150	0
11	Analyser Down		
12	Analyser Down		
13	Analyser Down		
14	Analyser Down		
15	Analyser Down		
16	Analyser Down		
17	Analyser Down		
18	Analyser Down		
19	Analyser Down		
20		>150	>150
21		>150	0
22		>150	>150
23		>150	>150
24		>150	72
25		>150	54
26		>150	74
27		>150	>150
28		>150	117
29		>150	>150
30	Mill Down		
31	Mill Down		
86 04 01	Mill Down		
02	Mill Down		
03	Mill Down		
04	Mill Down		
05		>150	0
06	Analyser Down		
07	Analyser Down		
08		>150	35
09		>150	>150
10		>150	0
11		>150	
12		>150	
13		>150	
14		>150	

Celgar Pulp Company Emission Data
Recovery Boiler; TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 04 15		>150	48
16		>150	37
17		>150	64
18		>150	40
19		>150	0
20		>150	59
21		>150	0
22		31	0
23	2	71	0
24	13	132	0
25	26	>150	0
26		>150	0
27		>150	0
28		>150	0
29		>150	35
30		>150	0
86 05 01		>150	0
02		>150	0
03		>150	0
04	Analyser Down		
05	Analyser Down		
06	Analyser Down		
07	Analyser Down		
08	Analyser Down		
09	Analyser Down		
10	Analyser Down		
11	Analyser Down		
12	Analyser Down		
13	Analyser Down		
14	Analyser Down		
15	Analyser Down		
16	Analyser Down		
17	Analyser Down		
18	Analyser Down		
19	Analyser Down		
20	Analyser Down		
21	Analyser Down		
22	Analyser Down		
23	Analyser Down		
24	Analyser Down		
25	Analyser Down		
26	Analyser Down		
27		>150	0
28		>150	0
29		>150	0
30		>150	0
31	6	115	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 06 01		>150	0
02		>150	0
03	12	>150	0
04	13	88	0
05	47	141	0
06	28	>150	0
07		>150	0
08		>150	0
09		>150	43
10		>150	0
11		>150	47
12		>150	0
13	Analyser Down		
14	Analyser Down		
15	Analyser Down		
16	Analyser Down		
17	Analyser Down		
18		>150	>150
19		>150	0
20		>150	0
21		>150	0
22		>150	0
23	Analyser Down		
24		>150	>150
25		>150	72
26		>150	63
27		>150	0
28	Analyser Down		
29		>150	
30		>150	
86 07 01	Analyser Down		
02		>150	0
03	Analyser Down		
04	65	>150	0
05		>150	39
06		>150	0
07		>150	0
08	Analvser Down		
09		>150	37
10		>150	0
11		>150	52
12		>150	0
13		>150	0
14	Analyser Down		
15		>150	0
16		>150	0
17		>150	0
18		>150	51

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 07 19		>150	40
20		>150	62
21		>150	>150
22	Analyser Down		
23		>150	>150
24		>150	0
25		>150	0
26	Analyser Down		
27	Analyser Down		
28		>150	16
29		>150	0
30	Analyser Down		
31	Analyser Down		
86 08 01		>150	0
02		>150	>150
03		>150	0
04		>150	0
05	Analyser Down		
06	Analyser Down		
07	Analyser Down		
08	Analyser Down		
09	Analyser Down		
10	Analyser Down		
11		>150	0
12		>150	0
13	Analyser Down		
14		>150	0
15		>150	59
16		>150	49
17		>150	0
18		>150	>150
19	No Report		
20		>150	0
21		>150	0
22		>150	0
23		>150	>150
24		>150	0
25		>150	0
26		>150	0
27		>150	35
28	22	>150	0
29		>150	0
30	Analyser Down		
31	Analyser Down		
86 09 01	Mill Down		
02	Mill Down		
03	Mill Down		

Celgar Pulp Company Emission Data
Recovery Boiler; TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 09 04	Mill Down		
05	Mill Down		
06		>150	0
07		>150	0
08		>150	0
09		>150	0
10		>150	68
11		>150	53
12	90	>150	0
13	66	>150	0
14		>150	0
15		>150	0
16		>150	0
17		>150	0
18		>150	0
19		>150	0
20		>150	0
21		>150	0
22	18	>150	0
23		>150	0
24		>150	0
25		>150	0
26	58	>150	0
27	29	>150	0
28		>150	0
29		>150	0
30		>150	0
86 10 01		>150	0
02		>150	0
03		>150	0
04	42	>150	0
05	Analyser Down		
06		>150	39
07		>150	84
08		>150	56
09		>150	0
10		>150	0
11	52	144	0
12		>150	0
13		>150	>150
14		>150	>150
15		>150	0
16		>150	0
17	18	76	0
18		>150	0
19		>150	0
20		>150	0
21		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H2S (PPM)

Date	Average	Maximum	Minimum
86 10 22	Analyser Down		
23		>150	0
24		>150	0
25	48	>150	0
26		>150	28
27		>150	0
28		>150	0
29		>150	>150
30		>150	81
31		>150	139
86 11 01		>150	0
02		>150	0
03		>560	0
04		>434	0
05	Analyser Down		
06		>150	>150
07		>150	0
08		>150	0
09	Analyser Down		
10	Analyser Down		
11	Analyser Down		
12	Analyser Down		
13		>150	0
14		>150	0
15		>150	>150
16		>150	>150
17		>150	0
18		>150	0
19		>150	>150
20		>150	>150
21		>150	0
22	77	>150	0
23	16	>150	0
24	25	>150	0
25	15	136	0
26	15	>150	0
27		>150	0
28		>150	0
29	9	144	0
30	18	120	0
86 12 01		>150	0
02		>150	0
03	19	137	0
04	5	76	0
05		>150	0
06		>150	0
07		>150	0

Celgar Pulp Company Emission Data
Recovery Boiler: TRS emissions as H₂S (PPM)

Date	Average	Maximum	Minimum
86 12 08		>150	0
09		>150	0
10		>150	43
11	26	>150	0
12	72	>150	0
13	22	>150	0
14		>150	0
15		>150	0
16		>150	0
17		>150	0
18		>150	0
19	0	53	0
20		>150	0
21		>150	0
22		>150	0
23	Analyser Down		
24	Mill Down		
25	Mill Down		
26	Mill Down		
27	Analyser Down		
28	Analyser Down		
29	15	149	0
30		>150	0
31		>150	0



Celgar Pulp Company Emission Data

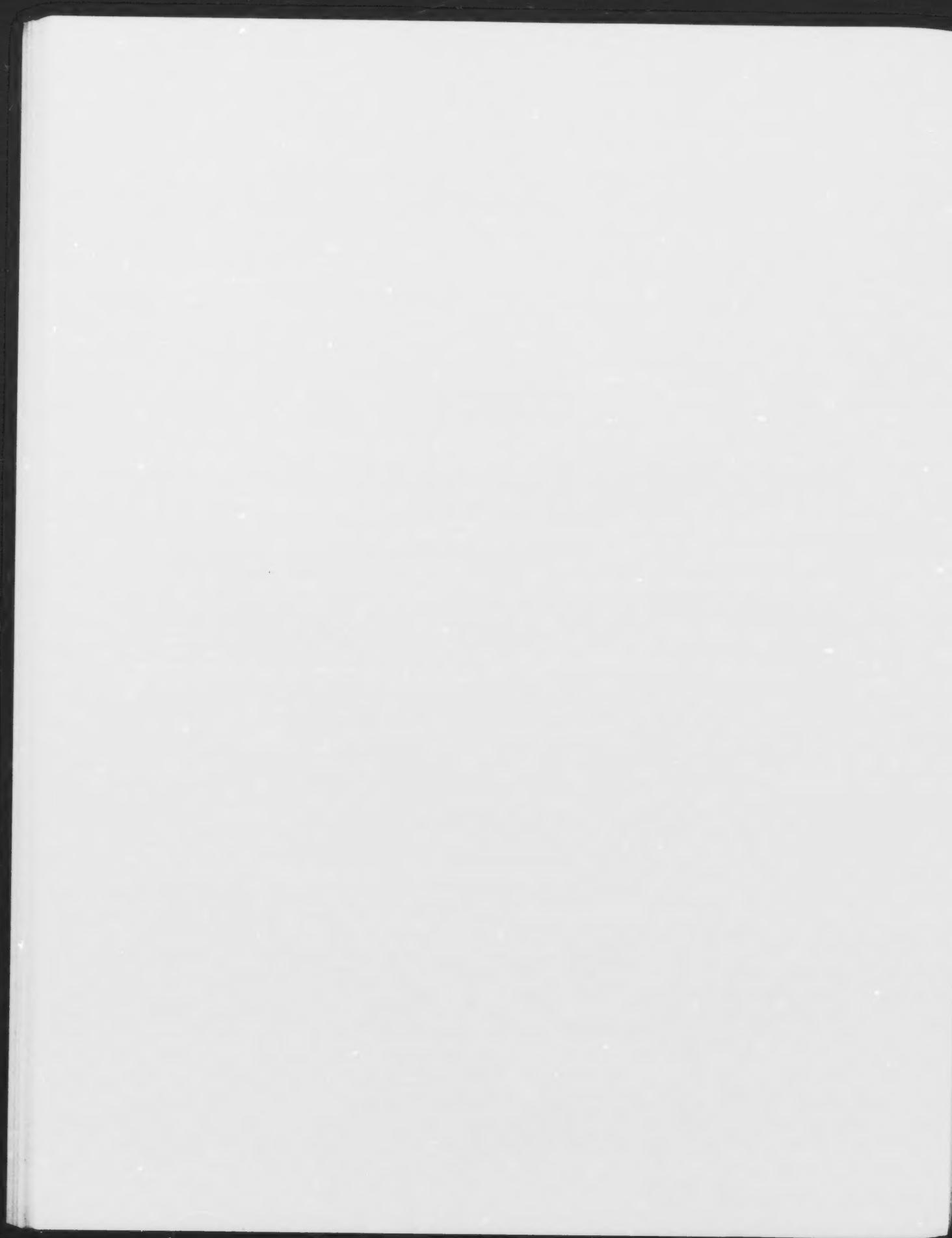
Date	Recovery Boiler disch. m ³ /s	1 Power Boiler disch. m ³ /s	Combined part. mg/m ³	2 Power Boiler disch. m ³ /s	part. mg/m ³	Line Kiln disch. m ³ /s	part. mg/m ³	Dissolving Tank disch. m ³ /s	part. mg/m ³	Non-condensable Gas Incineration System bivalent sulphur kg/ADUt
84 05	43	41	337							0.22
84 06	50	37	347							0.17
84 07	48	41	334			8	87	13	?	0.25
84 08	49	41	431							
84 09	59	39	270							0.26
84 10	50	43	326	24	153					0.10
84 11	54	40	283							0.23
84 12	53	39	216							0.31
85 01	55	39	293							0.15
85 02	51	45	172							0.29
85 03	46	39	432	27	192					0.12
85 04	53	39	496							0.21
85 06	55	41	450							0.3
85 07	51	42	407	26	98	10	193	12	78	0.33
85 08	53	47	279							
85 09	48	42	259							0.67
85 10	54	43	400							0.30
85 11	51	37	456	27	229					0.31
85 12	53	45	394							0.25
86 01	50	45	359							0.25
86 02	54	55	121							0.46
86 03	50	46	158	28	96					0.22
86 04	47	43	340							0.28
86 05	50	42	344	25	192	8.2	48	11.9	96	0.69
86 06	49	42	228							0.50
86 07	53	44	254							0.36
86 08	55	43	352	26	243					0.34
86 09	54	44	167							0.43
86 10	53	42	324	28	263					0.24
86 11	46	43	438							0.10
86 12	59	48	282							0.25

Note:

Emission figures prior to June 1984 are available through the Ministry of Environment and Parks, Waste Management Branch, 310 Ward Street, Nelson, B.C.

Appendix III

An assessment of some factors which may influence sulphation rate



Appendix III

An assessment of some factors which may affect sulphation rate

Sulphation rate data are gathered as indicators of long term trends in atmospheric sulphur gas levels. There are questions about what these data represent and hence what conclusions can be drawn from them. This appendix has been included to discuss some of those questions.

1. Between 1971 - 1980, both the Ministry of Environment and Parks and Cominco Ltd. gathered sulphation rate data at the Castlegar Airport. There is no documentation of the location of these collection sites; as best as we can determine they were side by side on the roof of the Adastra Air hangar. The results of the two data sets (Figure A1) show a marked similarity but also distinct differences. They show the same seasonal variation with a peak in the winter and low levels in the summer. However, the Ministry of Environment and Parks data show a higher peak in the winter, and this difference is relatively consistent.

One possible explanation for this difference is contamination of the Ministry station (and not the Cominco station) by the exhaust fumes of the hangar heating system. The winter peaks coincide with the heating season and the exhaust fumes of a diesel heating system would contain some sulphur gases (T. Leung, Ministry of Environment and Parks, pers. comm., 1987). This explanation presupposes that the two stations were separated by some distance on the roof of the hangar.

The above situation illustrates how two stations in the same geographic vicinity can yield different results. This obviously influences the interpretations which such data can support.

2. An attempt was made to assess the effect of elevation on the sulphation rate using six of the Cominco Ltd. stations. Data from three pairs of stations were graphed (Figure A2). The two stations of each pair are approximately the same distance from the smelter but at different elevations. Between 3.0 and 3.9 km from the smelter the higher station shows distinctly elevated levels of atmospheric sulphur during the winter. Between 7.6 and 8.9 km from the smelter the lower station shows generally higher levels, however the difference is not as consistent nor as great. As well, the elevation difference between these two stations is not as great as between the previous pair. Between 12.4 and 13.4 km from the smelter there appears to be little difference between the two stations. Also, this final pair is lower in the valley than are the other two.

According to conventional wisdom, the emission plume would rise to an equilibrium height and drift with the air mass at that height. Subsequently the plume would diffuse into a cone around this elevation. The speed of this diffusion will depend on the stability of the atmosphere. Regardless of this rate the maximum concentration of plume components should remain at or near the equilibrium elevation. Furthermore, this elevation should not change unless other factors act on the air mass to change its

density, which would in turn change the equilibrium elevation of the emission plume.

The data from the first and third pairs of stations are consistent with the above explanation; they indicate a maximum difference in plume component (SO_2) concentration close to the emission point and a decreasing difference with distance. However, the data from the second pair do not conform to the explanation, as it is not likely that the plume will "sink" as it moves up the valley.

This analysis does not indicate a consistent effect of elevation. There may be another, or indeed many other, factors involving the interaction of airflow and geography that are overriding and counteracting any elevation effect. Indeed, variations in the rate of collection of atmospheric sulphur by the sulphation plates resulting from micro-climatic differences at each site cannot be discounted. For example, it is known that sulphation rate varies with air motion over the collection surface (Liang et al., 1973; Lynch et al., 1978), therefore it is possible that some of the variation among the sites could be explained by micro-geographic differences, i.e. one station being positioned in a small clearing while another is in a large clearing exposed to the wind.

Given the consistency of this data pattern over time it is likely that it indicates a valid difference among the sites. However, it is impossible to define what the possible cause(s) of these differences might be with the data currently available.

3. It is thought (McQuaker, Environmental Laboratories, pers. comm. 1987) that the lead oxide collection medium will react with sulphur dioxide and hydrogen sulphide with similar rates and efficiency. The sum of the daily average for each month of the sulphur dioxide and total reduced sulphur compound levels should be a reasonable estimate of the total atmospheric sulphur gases capable of reacting with the sulphation plates. To test this theory three data sets were graphed: the sulphation rate and the aforementioned sum at two stations in Prince George, and the sulphation rate and the daily average sulphur dioxide level from a station in Trail (Figure A3). These graphs show a reasonable correlation with large changes in ambient sulphur gas levels but a poor correlation with smaller changes.

The components of the sum (sulphur dioxide and total reduced sulphur compounds levels) were also graphed and compared to the sulphation rate for the Provincial Jail station (Prince George) (Figure A4). It appears that the sulphation rate variation is more closely related to the levels of ambient sulphur dioxide than the levels of total reduced sulphur gases. However the variation in recorded levels of ambient sulphur dioxide is greater than the variation in recorded levels of total reduced sulphur gases. This brings to mind the question: does the stronger correlation merely reflect the scale of variation or a difference in the reaction of the sulphation plate to the various chemicals involved?

As well, it cannot be stressed too highly that this discussion is based on a small sample size over a relatively

short period of time (one year).

The purpose of this discussion is to raise some questions and to give some idea of the number and variation of possible explanations for the observed data. The reader can then reflect on the value of sulphation rate data. The purpose of this appendix is not to negate the value of this data, as one of the main conclusions of the preceding report is drawn from such data. However, to derive any defensible conclusions regarding trends in air quality one needs sulphation rate data from many stations over a long period of time. In this way, the preceding discussion demonstrates the value of the sulphation rate data base collected by Cominco Ltd. in the Trail/Castlegar area.

The main conclusion which can be drawn from the preceding discussion is that there is a need for more research into the relationship between sulphation rates, as gathered using lead oxide plates, and the atmospheric pollutants of concern. Some of this research can be done through detailed analysis of existing data, analyzing all the available data pairs (i.e. those stations where both sulphation rate data and continuous atmospheric sulphur dioxide and/or total reduced sulphur compound data are gathered) in a similar but more rigorous manner.

Furthermore, this analysis suggests that using sulphation rate data from one or two stations in an area to assess long term variation and atmospheric sulphur levels could result in an inaccurate or misleading assessment of conditions.

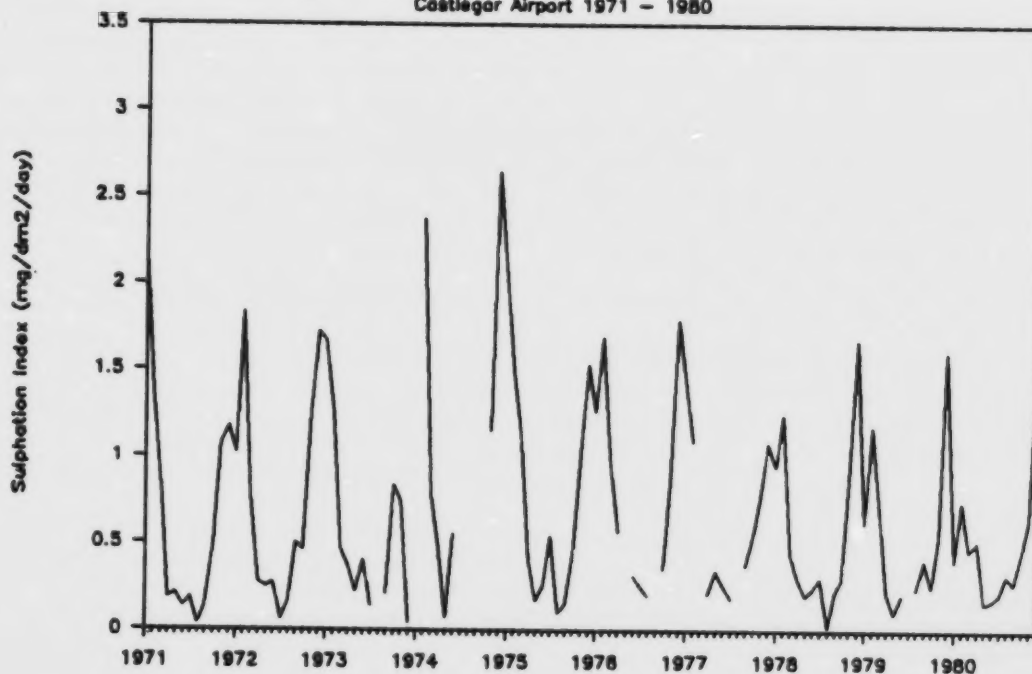
References

Liang, S.F., C.V. Sternling and T.R. Galloway. 1973. Evaluation of the effectiveness of the lead peroxide method of atmospheric monitoring of sulphur dioxide. *Journal of Air Pollution Control Association*. 23(1):605 - 607

Lynch A.J., N.R. McQuaker and M. Gurney. 1978. Calibration factors and estimation of atmospheric SO₂ and fluoride by use of solid absorbents. *Environmental Science and Technology*. 12(2):169 - 173

Cominco Ltd.

Castlegar Airport 1971 - 1980



Ministry of Environment and Parks

Castlegar Airport 1971 - 1980

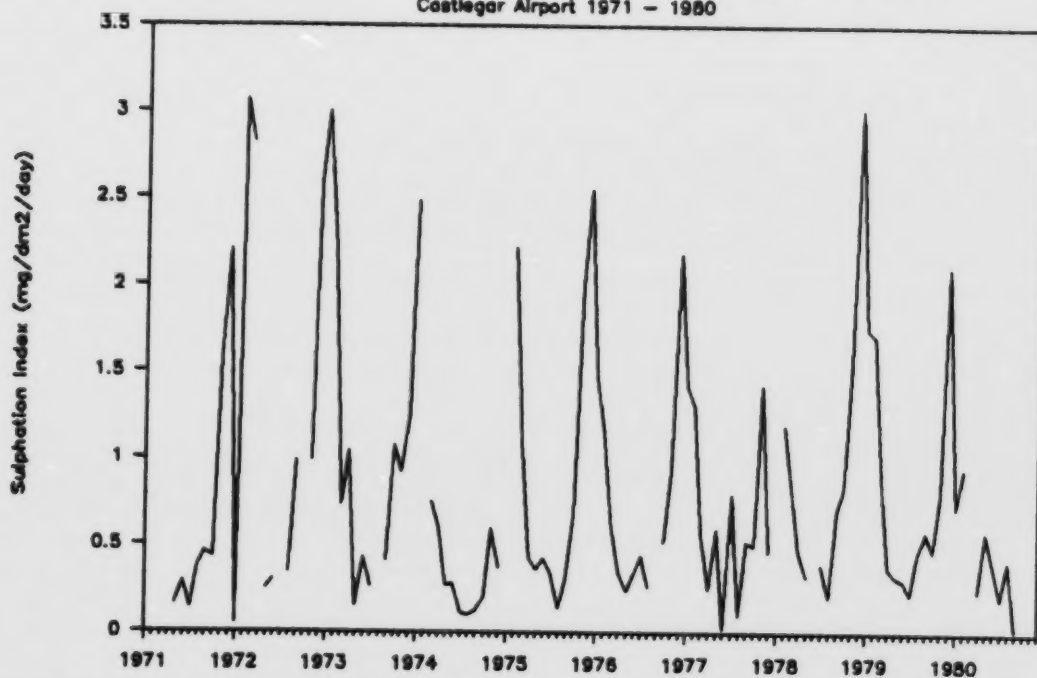
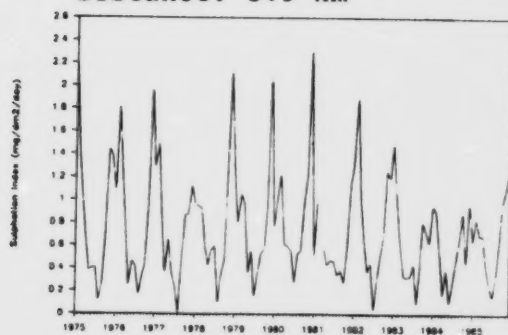


Figure A1: Graphs of the sulphation rate data collected at two stations on the roof of the Adastral Air hangar at Castlegar Airport.

Oasis

Elevation: 549 m

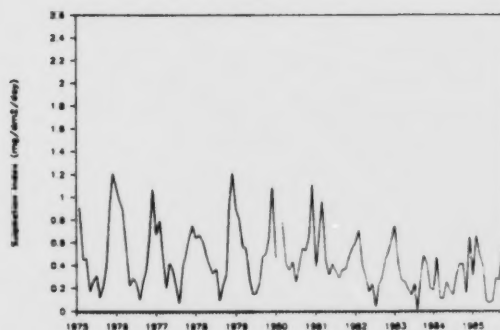
Distance: 3.9 km



Rivervale

Elevation: 411 m

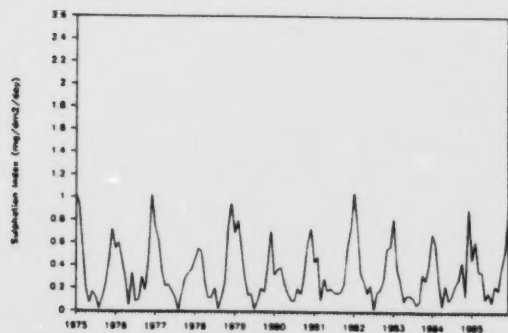
Distance: 3.0 km



Birchbank

Elevation: 533 m

Distance: 8.9 km

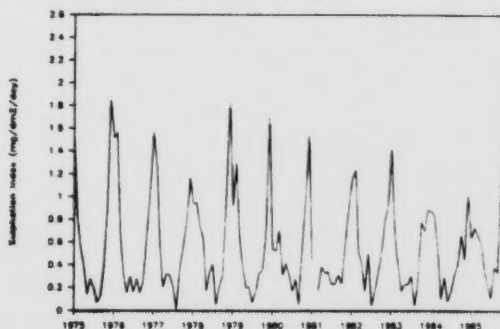


Birchbank

Golf Course

Elevation: 481 m

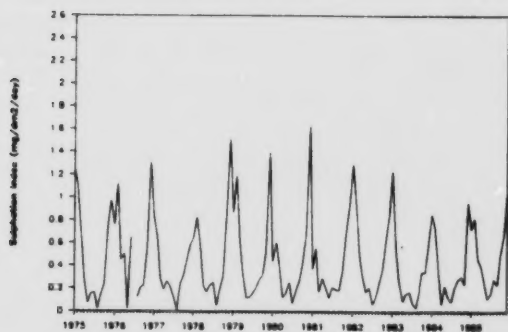
Distance: 7.6 km



China Creek

Elevation: 487 m

Distance: 13.4 km



Genelle

Elevation: 426 m

Distance: 12.4 km

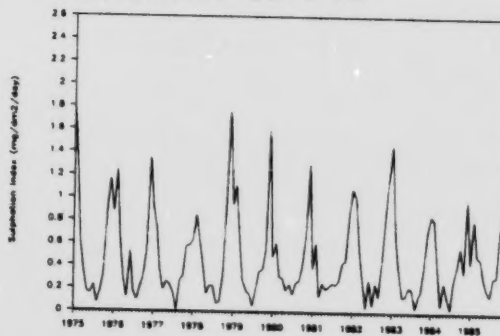


Figure A2: Graphs of sulphation rates at six stations at varying elevations and distances from Cominco Ltd. operations.

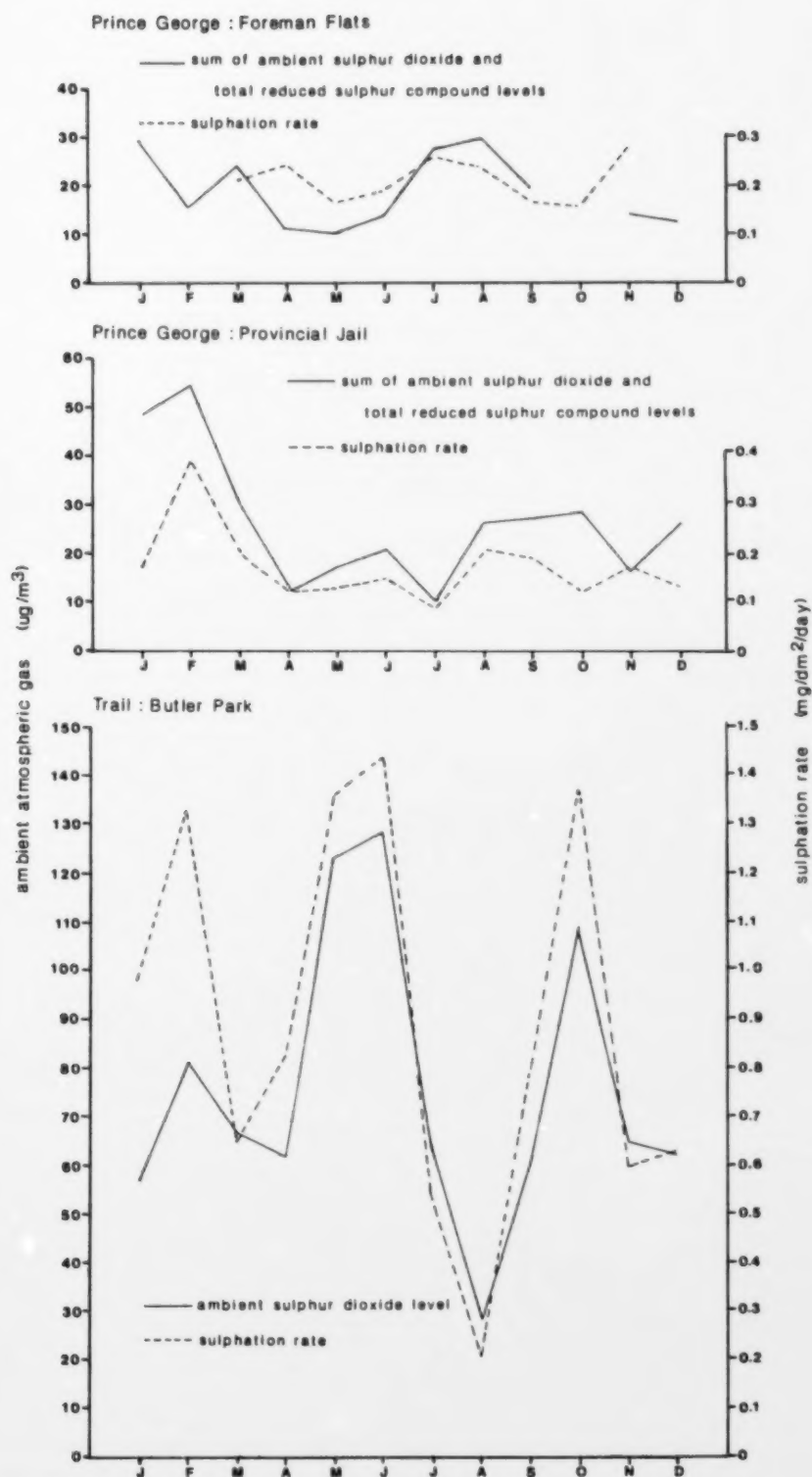


Figure A3: Graphs showing the "index of available atmospheric sulphur" and sulphation rate for three stations.

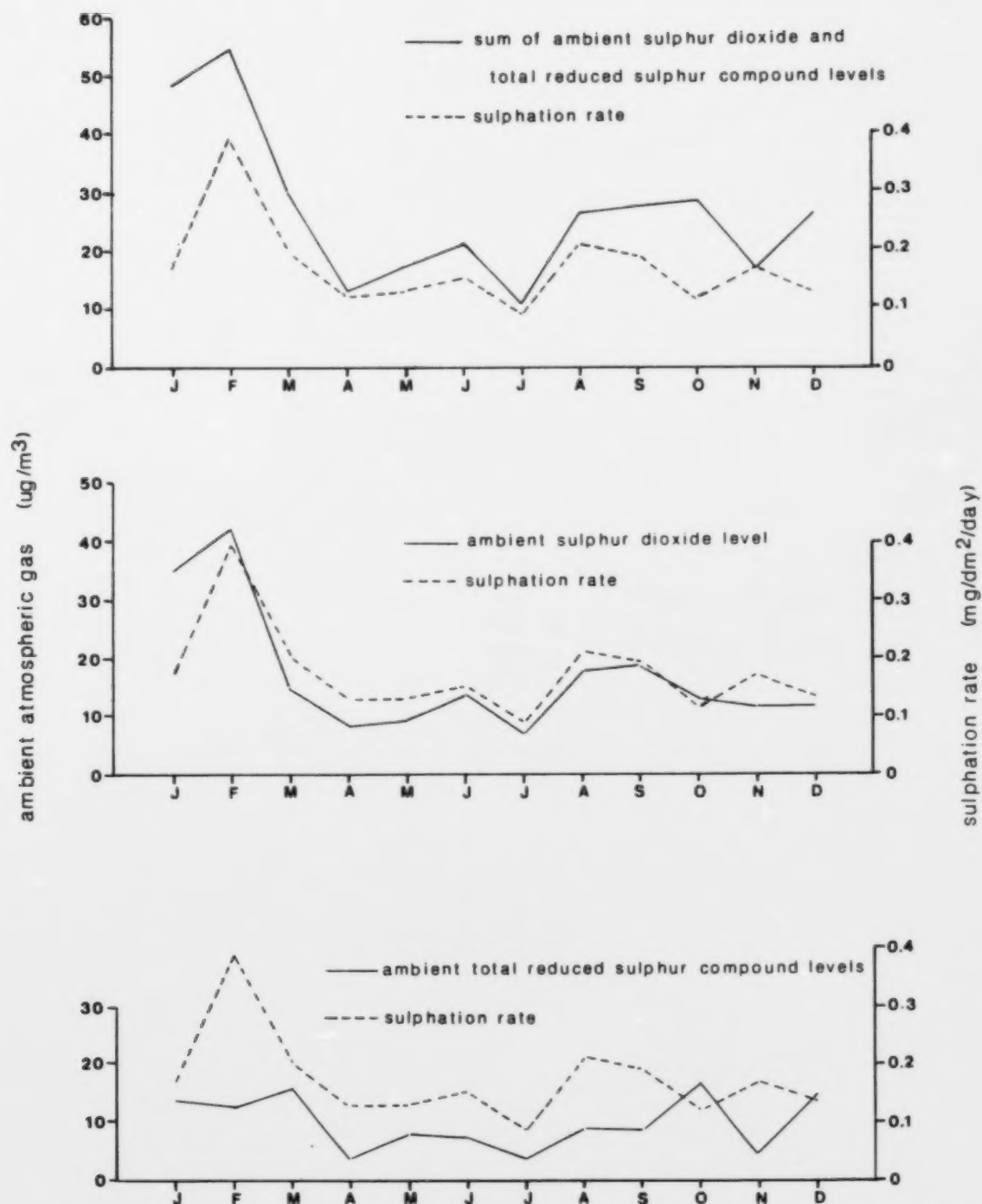


Figure A4: Graphs showing the variation in sulphation rate and the "index of available sulphur", the monthly average value for total reduced sulphur gases and sulphur dioxide at the Provincial Jail monitoring station in Prince George.